POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

Contents

Seams are not What They Seem 304

With the Editor 305

New Sources of Energy. Electric Utility NRA Code Rejected.

Electrical and Mechanical Features of the Field Building 306

Combustion Control for Power Plants. By Gustaf A. Gaffert 314

X-Raying 400,000 Feet of Welding at Boulder Dam. By Robert G. Skerrett 316

Figuring a New Winding for an Old Motor. By C. C. Herman 318

Power Station Building Costs 320

Selection of Equipment for Economy. Part II. By Linn Helander 321

Revamped Heating System Presents Difficulties. By Fred S. Rutledge 324

Factors Influencing the Parallel Operation of Alternators. By V. E. Johnson 326

Coal Car Thawing Equipment 329

Baffle Changes Reduce Maintenance. By Julian E. Tobey 330

Comparative Cost of Fuels for Power Plant Use. By H. M. Faust 332

Coal Classification by Grade and Rank Completed 334

Economies Effected by Use of Return Trap. By Leo P. Flood 336

Scavenging of Two-Cycle Diesel Engine 338

Readers Conference 340

Maintenance of Chain Conveyors. Use of Remote Synchronizing Lamp. Get Ready for Cold Weather Now. Depth Micrometer Used to Determine Diameter. Visible Small Ware Container. A Street Lighting Problem from the Standpoint of Economy and Safety. Building a Spot Welder.

Freon Compressors. Brown Indicating Thermometer Controller. Eclipse Photoelectric Smoke Detectors. Improved Surge-Crest Ammeter. 344

Thermo Master Regulator. Keckley Pressure Regulating Valve. H-O-H Feeder System. 345

New Mason-Neilan Recording Thermometer. Walseal Threadless Bronze Fittings. Opposed Piston Diesel Engine. Instant Water Heater Improvements. Lowering Relay for Crane Operations 346

Assembling Philadelphia Electric Company's New Turbo-Generator. Coal Utilization Course at U. of Ill. Hartford E. L. Co. Presented Coffin Award. William Mitchell McKee 347

News from the Field 348

For the Engineer's Library 349

Power Plant Construction News 350

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

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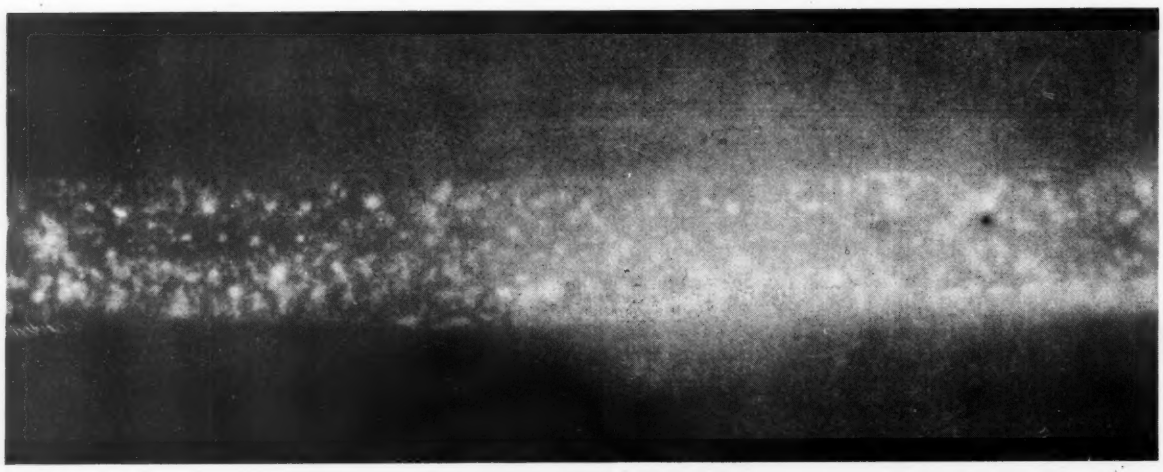
SEAMS *are not what they* SEEM



ONE OF THE FACTORS which has delayed the more rapid adoption of fusion welding for equipment to be subjected to high stress was the uncertainty regarding the correctness of the weld. A riveted joint or seam bears face-value evidence regarding its strength; despite the fact that the rivets may be unduly stressed, the appearance of a riveted joint invokes confidence. This is not so with a welded joint; regardless of how well it is made, how firm it appears from the outside, one always wonders what the inside looks like—whether the seam is really as strong as it seems. And sometimes, though rarely so, an apparently healthy looking welded seam is not very solid inside, such as for example, the one shown above. This seam looked "well done" from the outside but when the penetrating eye of the X-ray was focused upon it, this is what it revealed—slag inclusions and a high degree of porosity.

The work of X-raying 400,000 ft. of welded seam in 14,500 ft. of pipe is only one of many interesting features of the construction of these pipes for Boulder Dam. For these pipes, you may know, are being fabricated from flat steel plate right at the dam. Imagine, building a complete fabricating plant, capable of turning out steel pipe 8½ to 30 ft. in diameter, and from ⅞ to 2¾ in. thick, right smack out in the middle of the desert! Yet, as pointed out on page —, that's what they did—not only built it, but are operating it and turning out work as perfect and as rapidly as though in Akron or Barberton or Pittsburgh. It is interesting, but somehow it leaves us a little sad. The desert, we had always thought, would be one place on earth to resist the ever spreading influence of civilization—the one place where one could find solitude and relaxation, but now it seems even this last outpost of the wilderness is to fall—even the Gila monster and lizards will have to move to escape the din of the boiler factory—but we forget, this is a welding plant so probably there isn't much din.

• • •

A provision of the Marshall Field will was that a certain portion of the income from the estate was to be reinvested in real estate. This is the reason for the magnificent new Field Building in Chicago, the electrical and mechanical features of which are described in the leading article of this issue. Projecting its attractive architecture 45 stories above the Chicago loop, this building is the largest in the city and the fourth largest in the country. Mechanically and electrically it is as interesting as its architecture and general design are attractive. We can't go into detail here but the description in this issue though brief will give you an excellent conception of what the modern office building contains.

• • •

Parallel Operation is with us again. Of all the factors involved in the operation of electrical equipment few have received so much discussion as the parallel operation of alternating current generators. When all other subjects fail to create interest, the mention of parallel operation is usually sufficient to invoke lively discussion. Perhaps this is only natural, a consequence of the widespread prevalence of the practice. Like many other things in electrical engineering though really complex in its fundamental nature, parallel operation is quite simple in practice and one has no trouble in operating two or more alternators in parallel even though he has never seen a vector diagram.

But to really understand what is happening in the circuit, a few vector diagrams are of considerable value and to one who can draw them they become formidable weapons in an argument. Their very appearance usually is sufficient to silence the most garrulous wire splicer and when you say "the length of this line and its angle proves that you're all wrong" he has no "come back."

In this issue V. E. Johnson presents the first of two articles involving a most comprehensive analysis of the whole question of parallel operation. Mr. Johnson has been a frequent contributor to these pages for many years and we are pleased to have him back again to present this interesting discussion of this subject.

With the Editors

New Sources of Energy?

IN A RECENT address at A Century of Progress Exposition in Chicago, Dr. Willis R. Whitney of the General Electric Co. referred to a tiny electric motor running directly by sunlight. In itself this is, perhaps, of little importance—the mere fact that a small motor can be built on this principle does not imply that the idea can be carried out on a large scale and that this will soon put all our power stations out of business. As a matter of fact, the little radiometers which have occupied the windows of optical dealers for many years are sun motors but they have never developed into anything practical for power purposes.

Dr. Whitney's reference is important, however, in view of the fact that this is only one of many developments concerned with the question of obtaining energy directly from sources other than those which have served us in the past. Many things happening today in the field of fundamental physics are of little importance in themselves but taken as a whole they represent a great increase in our knowledge of the secrets of matter and energy. While it is unwise to make predictions regarding the success or non-success of any of the new possible energy sources the sum total of the knowledge which is being accumulated is bound to exert its influence in a profound way.

Just a few days ago the news of Prof. Firmi's recent experiments in Rome reached us. Dr. Firmi has produced a new element—element No. 93—by bombarding uranium with non-electrical particles known as neutrons. Thus for the first time in history man has actually created a new element, one which we had not known of before. Professor Firmi's experiments have not yet been verified but theoretically there is no reason why the reports should be doubted, for Eddington and others have indicated the possibility of such "higher" elements.

The new element is radioactive, that is, it emits alpha, beta and gamma rays and thus keeps changing continually. Its half life is only 13½ min.; that is, a given amount decays to half this amount in 13½ min.

But if Professor Firmi's experiments are startling, so are many others recently made. Indeed it is only since the beginning of 1934 that the technique of creating radioactivity in normal stable atoms has been known. By bombarding boron with alpha particles, Professor F. Joliot and Mme. Irene Curie-Joliot only a short time ago induced the boron to become radioactive. In a similar manner aluminum and magnesium were made radioactive.

In view of all these developments, the status of physical science must seem very confusing to the layman who has only a superficial knowledge of these things and indeed, even to the scientists these things are startling. But the scientist knows that this apparent confusion is only the consequence of the rapid development and that in the end, the confusing elements will arrange themselves in orderly fashion, with probably far-reaching results. Just at present we are gathering facts—the analysis will follow.

So too with our new sources of power. It is too early to say whether a motor running by sunlight or cosmic rays will provide the unlimited supply of energy we have been striving for, but it is unwise to imply its negation. Great, high voltage equipment is almost completed for conducting new and more penetrating researches into the structure of the atom, and in various parts of the world powerful instruments are being built for observation and study of the cosmic rays. Those who have seen the Hodoscope work in the Hall of Science at A Century of Progress know that cosmic rays are no idle fantasy. Whatever their nature or origin, they are real and eventually they may endow the human race with new and undreamed of possibilities.

Electric Utility NRA Code Rejected

AFTER MONTHS of work by electric utility representatives in formulating a code satisfactory to the industry and more months during which hearings have been conducted by NRA officials, Administrator Hugh S. Johnson announces that the code has been returned, unapproved, to NRA by the White House. Mr. Johnson says: "I don't think the utilities code is so terribly necessary."

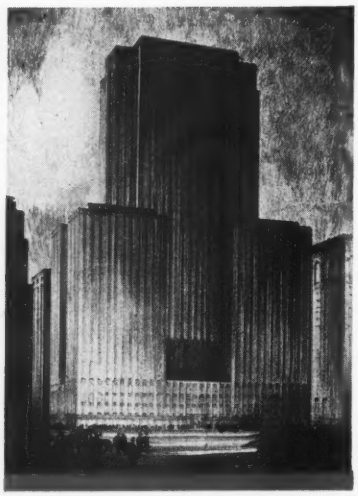
Electric utility companies were among the first to sign the general code submitted by NRA but when the Edison Electric Institute submitted a proposed code drawn up especially for this industry, controversy immediately settled around the following paragraph:

"Fair trade and the policy of the Act require that all persons and corporations engaged in the electric light and power business as defined, whether as individuals, private corporations, municipal or quasi-public corporations, or other governmental agencies, or authorities, in competition with others engaged therein, should be subject to the same, or to substantially the same, terms and conditions as to maximum hours of labor, minimum wages, conditions of employment, general labor provisions, and industry practices; and that where a member of the Industry is subjected to competition therein by a plant or enterprise which is not conforming to such requirements of this Code, such member of the Industry shall, on application to the Code Authority approved by the Administrator, be equitably exempted from the operation of this Code within the groups or areas affected by such competition."

The acceptance of this paragraph in the code would bring just what socialistic-minded politicians do not wish—fair competition between government owned and privately owned utilities. It would seem that the Administration has rejected the code for political reasons but thus far has been fair in that no code of its own drafting has been forced upon the industry and the apparent intention is to allow the industry to operate without a specific code. Certainly unless a code of unquestionably fair practice can be formulated, the industry is better without any.

Electrical and Mechanical Feat

THE FIELD BUILDING



PLACES, LIKE PEOPLE, have their destinies which time fulfills. La Salle Street from the beginning has been the financial heart not only of Chicago but of the great Middle West. Nearly a century ago, the first legitimate bank took up its pioneer abode in La Salle Street; today it is the financial center of a vast productive empire, the home of billion dollar banking institutions, of the famed Chicago Board of Trade, of more than half of Chicago's four hundred odd investment houses. It is the site of a magnificent group of office buildings rivalled only by New York; sky scraping structures whose impressive architecture reflect the solidarity and integrity of the institutions they represent.

Newest among these vast monuments to financial and commercial enterprise is the Field Building, Chicago's largest office building and fourth in size of any building in the country. Rising a sheer 533 ft. above the street, this 44 story structure is strikingly impressive by virtue of its simplicity and the clean cut handling of its masses. The dominating tower, far from being a mere set back, appears as a structural unit, rising straight from the ground and set about with four perfectly proportioned wings coming to the 23rd level.

While it would be interesting to discuss the structural and architectural features of this newest addition to the Marshall Field Estate, it is our purpose in this article to consider rather, the electrical and mechanical features of the building. For these are of the most modern character, incorporating every improvement that the arts of mechanical and electrical engineering have developed in this field. No effort or expense has been spared to make this the most completely up-to-date office space in Chicago.

This is the only building, for example, having enclosed radiation throughout in the heating system. Heating units are recessed under the windows flush with the walls, completely concealed in metal enclosures. All heating pipes are concealed. There is an ultra modern drinking water system in which distilled, aerated, filtered re-mineralized and cooled water is conveyed to every office through tin lined pipes. The entire building is ventilated by large fans equipped with air filters and ozonizers and the basement and first four floors are fully air conditioned. Another outstanding feature is the alternating current system of electrical distribution permitting the use of electric clocks, alternating current radio receivers, etc., and finally, there is installed the most up-to-date elevator system to be found anywhere. The elevator system in fact far surpasses any other Chicago building in its service requirements. Direct tower service is provided by a tier of eight elevators operating at a speed of one thousand feet per minute!

Of these various elements comprising the mechanical and electrical service features, the electrical system is the most outstanding, particularly in point of development. For the Field Building not only embraces the city's first alternating current, vertical network but is also the first to use aluminum bus risers for secondary distribution.

The use of alternating current was decided upon principally because the large load imposed by this new building upon an already heavily loaded direct current district would have necessitated great additions to the existing direct current supply system in the loop. With the use of alternating current, the 20,000-v. primary feeder cables from the generating stations of the Commonwealth Edison Co. are brought directly into the building—to the upper floors in fact.

The building occupies a ground area of 190 by 323 ft. and in the 44 stories there is over a million square feet of rentable area. The connected power load exceeds 5500-hp. and the connected lighting load, figured on the basis of 3 watts per sq. ft. for rentable area and lower values for public and service areas, is in excess of 4500 kv-a. The maximum demands for power and lighting are computed at 3500 kv-a., and 2300 kv-a. respectively. Thus, the total electrical demand for the

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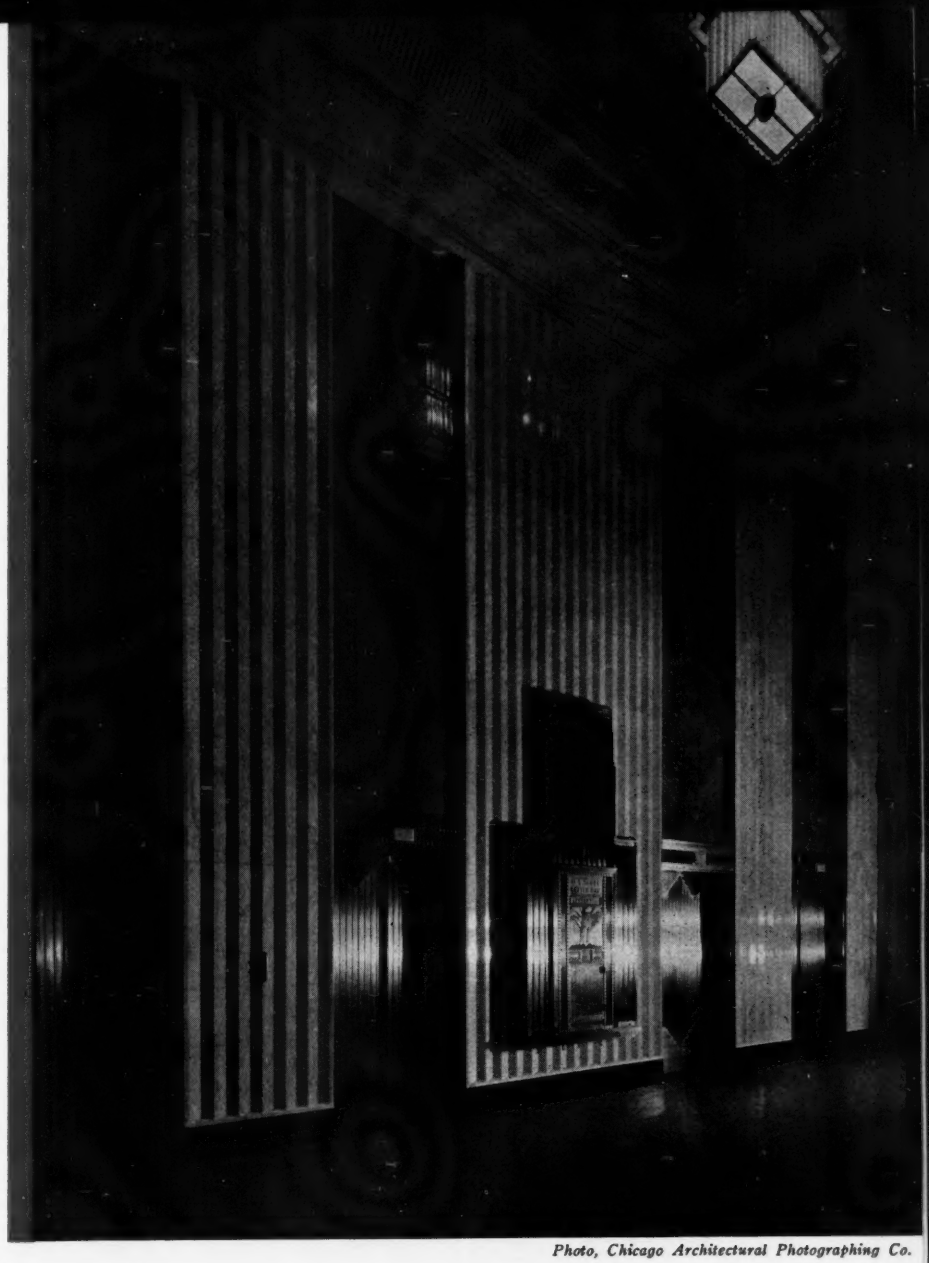


Elevator Signal Panel in First Floor Lobby is Replica of Building

Photo, Chicago Architectural Photographing Co.

entire building is about 5800 kv-a. Power is delivered over 12,000-v., 3-phase, 60-cycle circuits, to transformer stations within the building where it is transformed to 208/120 v. for distribution by the network

In the design of the low voltage electrical distribution system, two methods were available: First by the use of a single transformer vault and switchboard in the subbasement, and second, the installation of several transformer vaults feeding into a vertical a.c. network. Considering the height of the building and the size of the load, the first scheme would obviously have been excessively expensive, therefore the second was decided upon.

Comparison between the use of rigid bus and cable loops in conduit indicated that the cable loop type of construction would involve greater expense than the rigid bus arrangement. Hence, the rigid bus was adopted. Having decided in favor of rigid buses, the next question to be solved was the type of bus construction to use. As regards rigidity it was felt that copper tubing was superior to flat bus bar and because of the high current densities (1300 amp.) that might prevail at some points, flat buses would involve multiple arrangement of bars. Tubing, however, requires special clamping fittings.

Finally, therefore, channel shaped aluminum conductors were chosen. At the time the selection was made channel shaped copper conductors which are now on the market were not available but in a comparison of the two, the copper channel would not have been the winner.

There are four aluminum channel bus risers to the 24th floor of the main building, one in each corner and referred to as the N.W., S.W., N.E., and S.E. risers and two in the 20 story tower designated as the East and West tower risers. These risers are indicated in the accompanying diagram and are restricted to lighting service for the entire building.

The four risers in the main building are each served by bus feeders from the basement, the fourth and 24th floor switchboards, while the lower end of the East and West risers in the tower are served respectively by bus tie feeders from the upper end of the S.W. and S.E. risers. In addition the East and West risers are also served by bus feeders from the switchboard on the 44th floor level.

For the bus feeders and bus tie feeder sections, cable and conduit are used because of limited ceiling space. Power service throughout the building is provided from the power section of the four switchboards. This is convenient and desirable because the power centers are generally located on the same floor as the switchboards and in some instances only one or two levels below the switchboard.

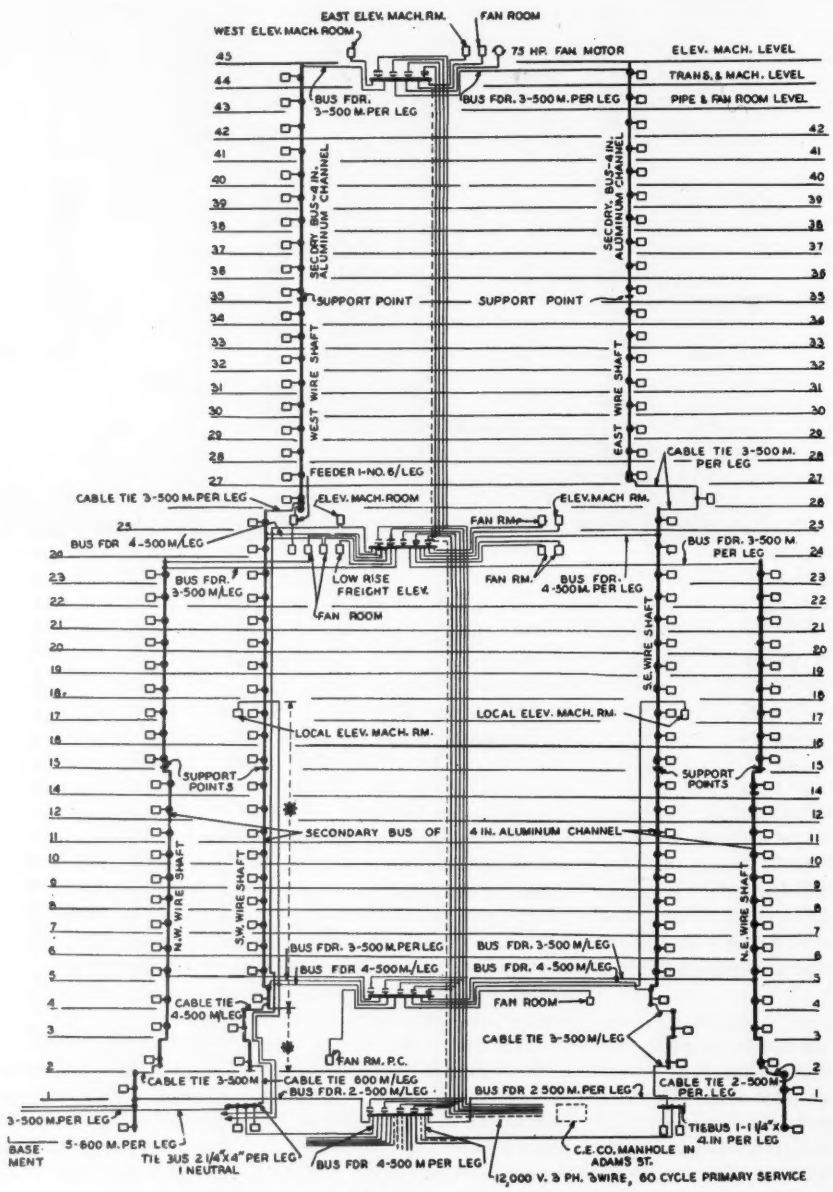
The use of aluminum for the risers presented many new problems, principal of which was the necessity of extreme care in obtaining low resistance electrical contact at the joints. The channel selected is standard electrical conductor made by the Aluminum Co. of America, 4 in. wide, running 2.51 lb. per foot, and

made of 99.4 per cent pure aluminum. Each of the six risers consists of a single channel for phases A, B and C and the neutral except that the lower half of the S.W. riser between the third and fifteenth floors comprise two channels for phases A, B and C and one for the neutral. The back channel of the two channel assembly for phases A, B and C continue above the fifteenth floor as phase channels for the remainder of the rise. These two arrangements are shown in Figs. 2 and 4.

An interesting feature of these buses is the manner of their support. They are supported at only one point throughout their entire length, i.e., at a point approximately at the center, thus eliminating expansion joints and intermediate supports. They are free to expand toward their upper and lower ends. The method of support is shown in Figs. 2 and 3. Steel angles bolted through the backs of the channels rest free in 3 in. by 3½ in. ebony asbestos, insulating blocks, which in turn are bolted to 3½ by 3½ by ⅜ in. steel angles secured to 3 in. No. 6 channels spanning floor beams adjacent to the bus enclosure. A rectangular transite enclosure is provided the full length of the bus.

With a maximum length of 248 ft. 9 in. for the highest risers and a support at their midpoint (the 15th floor in the main building) channels approximately 61 ft. long were provided. Thus, two lengths are used above the point of support and two below, requiring only 3 joints. In order to maintain proper alignment and interphase spacing, ebony asbestos spacer bars are provided at every floor. The distance between spacers was worked out on the basis of stresses set up by short circuits of approximately 25,000 amp.

In making joints and connections to the aluminum buses, all contact areas on the aluminum channels and splicing bars were scratch-brushed at the mill with applications of "No-Ox-Id" grade "A" compound. The contact surfaces of copper connections were also scratch-brushed in the shop. At the time of assembly the contact surfaces were given an application of No-Ox-Id compound thoroughly rubbed in with fine emery cloth and the assembly bolted together without removing any of this film. This method provided a nearly perfect joint and it is believed a better joint than can ordinarily be secured between bolted copper parts. A test showed that the joint resistance was less than that of a given section of the aluminum channels.


EAST ELEV. MACH. RM.
FAN ROOM
WEST ELEV. MACH. ROOM
75 HP. FAN MOTOR
ELEV. MACH. LEVEL
TRANS. & MACH. LEVEL
PIPE & FAN ROOM LEVEL
BUS FDR. 3-500 M. PER LEG
BUS FDR. 3-500 M. PER LEG
SECOND. BUS-4 IN. ALUMINUM CHANNEL
SECOND. BUS-4 IN. ALUMINUM CHANNEL
SUPPORT POINT
SUPPORT POINT
WEST WIRE SHAFT
EAST WIRE SHAFT
FEEDER 1-NO. 6/LEG
CABLE TIE 3-500 M. PER LEG
CABLE TIE 3-500 M. PER LEG
ELEV. MACH. ROOM
ELEV. MACH RM.
FAN RM.
BUS FDR 4-500 M/LEG
BUS FDR. 3-500 M PER LEG
BUS FDR. 3-500 M/LEG
LOW RISE FREIGHT ELEV.
FAN RM.
BUS FDR. 4-500 M. PER LEG
FAN ROOM
S.E. WIRE SHAFT
LOCAL ELEV. MACH. RM.
LOCAL ELEV. MACH. RM.
SUPPORT POINTS
SUPPORT POINTS
SECONDARY BUS OF
4 IN. ALUMINUM CHANNEL
N.W. WIRE SHAFT
S.W. WIRE SHAFT
N.E. WIRE SHAFT
BUS FDR. 3-500 M. PER LEG
BUS FDR. 3-500 M/LEG
BUS FDR 4-500 M/LEG
BUS FDR. 4-500 M/LEG
CABLE TIE 4-500 M/LEG
FAN ROOM
CABLE TIE 3-500 M/LEG
FAN RM. P.C.
CABLE TIE 3-500 M
CABLE TIE 600 M/LEG
BUS FDR. 2-500 M/LEG
BUS FDR 2 500 M. PER LEG
CABLE TIE 2-500 M PER LEG
3-500 M. PER LEG
BASEMENT
5-600 M. PER LEG
TIE BUS 2 1/4"x4" PER LEG
1 NEUTRAL
BUS FDR 4-500 M PER LEG
C.E. CO. MANHOLE IN ADAMS ST.
TIE BUS 1-1 1/4"x4 IN PER LEG
12,000 V. 3 PH. 3 WIRE, 60 CYCLE PRIMARY SERVICE

The Elevator System at the Field Building

The elevator installation at the Field Building as already implied represents the last word in efficiency and modern development. There are forty passenger elevators grouped in five banks of eight elevators each.

FIG. 1. A.C. VERTICAL NETWORK IN THE FIELD BLDG.

This is a simplified diagram showing the design of the a.c. distribution system in the Field Building. Three 20,000 v. primary mains from the generating stations feed four power centers, one in the basement, one on the fourth floor, one on the 24th and one on the 44th floor. At these centers power is stepped down to 208/120 v. and fed to the network. The network comprises 4 risers in the main building, one in each corner, running to the 24th floor and two in the tower. These risers are composed of aluminum bus channels, one for each phase and the neutral, suspended at only one point, i.e., in the center. This permits the channels to expand either upward or downward without the use of expansion joints. *Indicates double channel bus.

Duplicate elevator service is provided for the La Salle and Clark Street entrances,[1] each having eight locals and eight express cars. Direct tower service is provided by a tier of eight elevators operating at a speed of 1000 ft. per min.! Provision has been made also for the installation of private elevators between the basement and the fifth floor.

The two banks of local cars run to the 14th floor and operate at 600 ft. per min. The two banks of express elevators run to the 23rd floor and travel at 800 ft. per min. The tower elevators running at 1000 ft. per min. run to the 43rd floor.

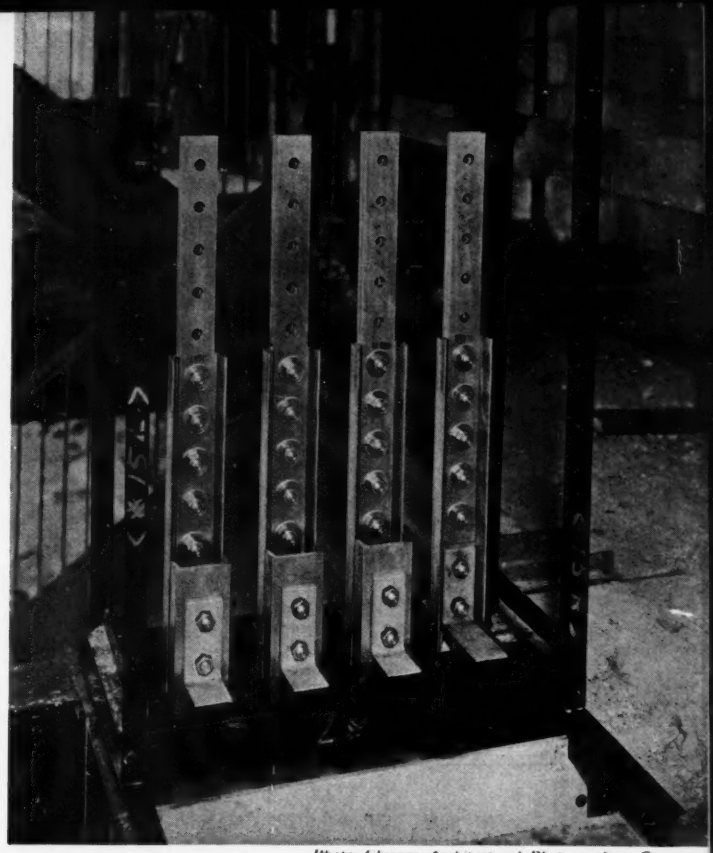
These elevators are all of the full-wrap traction type, made by the Otis Elevator Co. and operating from the 208-v. a.c. supply, through motor generator sets. Each elevator is provided with its own motor generator unit. The cabs are the most improved type built by the Otis Elevator Co. and are ventilated by large double rotating blade fans mounted on top of the car. This feature is of especial interest and was given lengthy and intensive study by the engineers of the Field Estate, the architects and the Otis engineers. As a result of study and tests the cars finally were equipped with fans with a capacity of 4000 cu. ft. of air per min., giving positive ventilation, regardless of the car's direction or drafts in the elevator shaft. There is a telephone in each car by means of which the operator can call the starter or in fact any part of the building or the pent houses. Further provision for perfect communication is involved in a series of jacks at various points in the machine rooms and in the pits so that the mechanics can plug in telephones and carry on conversation between themselves in any part of the system. In the cabs, the telephones are mounted in an enclosed compartment within easy reach of the control position.

A new feature of this elevator system is that the hall button signals are normally closed contacts. This is in contrast to the usual "open" contact system and has the advantage that if trouble develops at any of these contacts resulting in an "open," all cars will automatically stop at that floor. This will soon be noticed by the car operators but it will not inconvenience the tenants since cars will stop to pick them up, regardless of whether the car was stopped by them or because of the fault.

Another valuable new feature is an 8-sec. time element in the floor signal lanterns. These lanterns are also equipped with a gong so as to warn the passengers of the approaching car. The time element introduces an 8-sec. (this time can be varied) delay between the sounding of the gong and the lighting of the floor lamp and the arrival of the car at that floor, thus giving the person time to walk over to the proper door. This avoids delaying the car at the floor.

In the cabs, in addition to the car position indicator which indicates the position of the car at all times, there is a floor stop indicator. These elevators are, of course, of the signal control type. When the passenger enters the car and announces his floor to the operator, the operator presses the proper button in the usual manner. As he does so, however, the floor stop indicator above the door lights up, notifying the passenger that the car will stop at his floor and that no error has been made. The floor stop signal and the position indicator are combined in two rows of figures one above the other directly above the door

[1]The building covers the length of an entire block with the lobby running through from Clark to La Salle Sts.



Photo, Chicago Architectural Photographing Co.

Fig. 3. View of two channel assembly at 15th floor, showing splicer, bus supports, angle framework and portion of transite enclosure

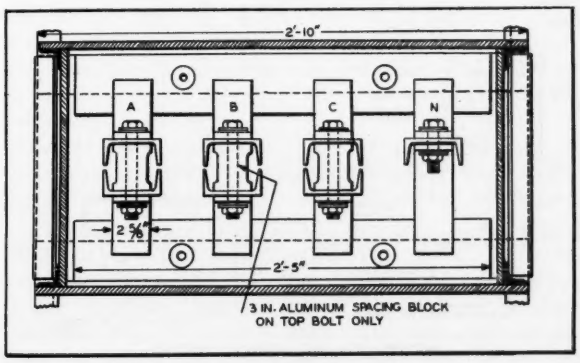


FIG. 2. PLAN OF TWO CHANNEL ASSEMBLY, BUS ENCLOSURE AND BUS SUPPORT AT 15TH FLOOR FOR S.W. RISER

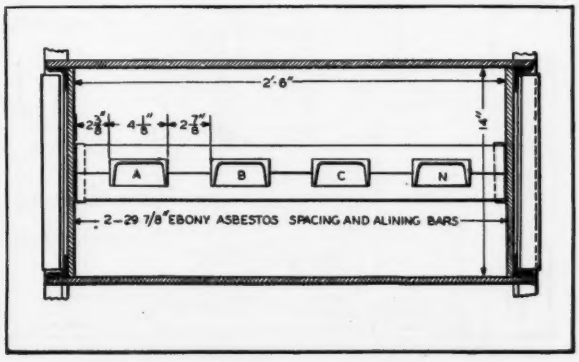


FIG. 4. PLAN OF SINGLE CHANNEL ASSEMBLY SHOWING SPACER AND ALIGNING BARS

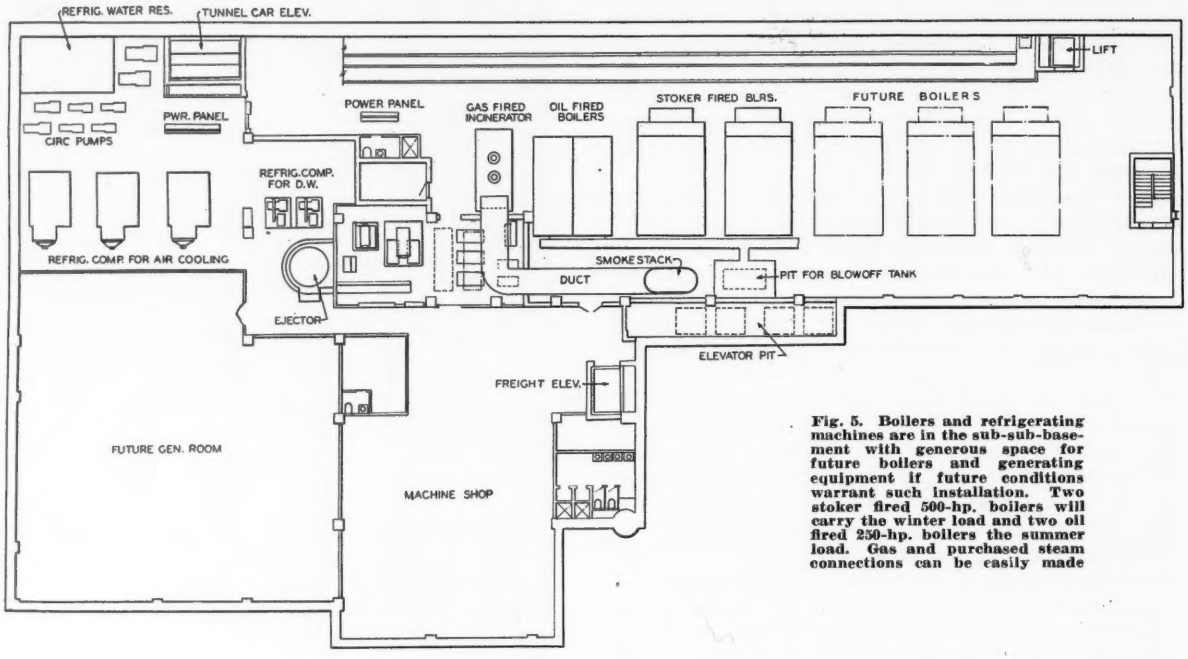


Fig. 5. Boilers and refrigerating machines are in the sub-sub-basement with generous space for future boilers and generating equipment if future conditions warrant such installation. Two stoker fired 500-hp. boilers will carry the winter load and two oil fired 250-hp. boilers the summer load. Gas and purchased steam connections can be easily made

in plain view of every occupant of the car. The cars are all equipped with two speed doors, entirely closed, which open and close automatically.

For use during the rush hours, the eight tower elevators and one car in each of the other four banks are equipped with an automatic reversing arrangement which obviates unnecessary travel of the cars. This system, when virtually all traffic is upbound, is so arranged that a car will automatically reverse its direction and start downward when it reaches the highest floor indicated by either the car signal control or by a signal from a waiting passenger. This system can also be used at night.

Every facility for testing and maintaining the sys-

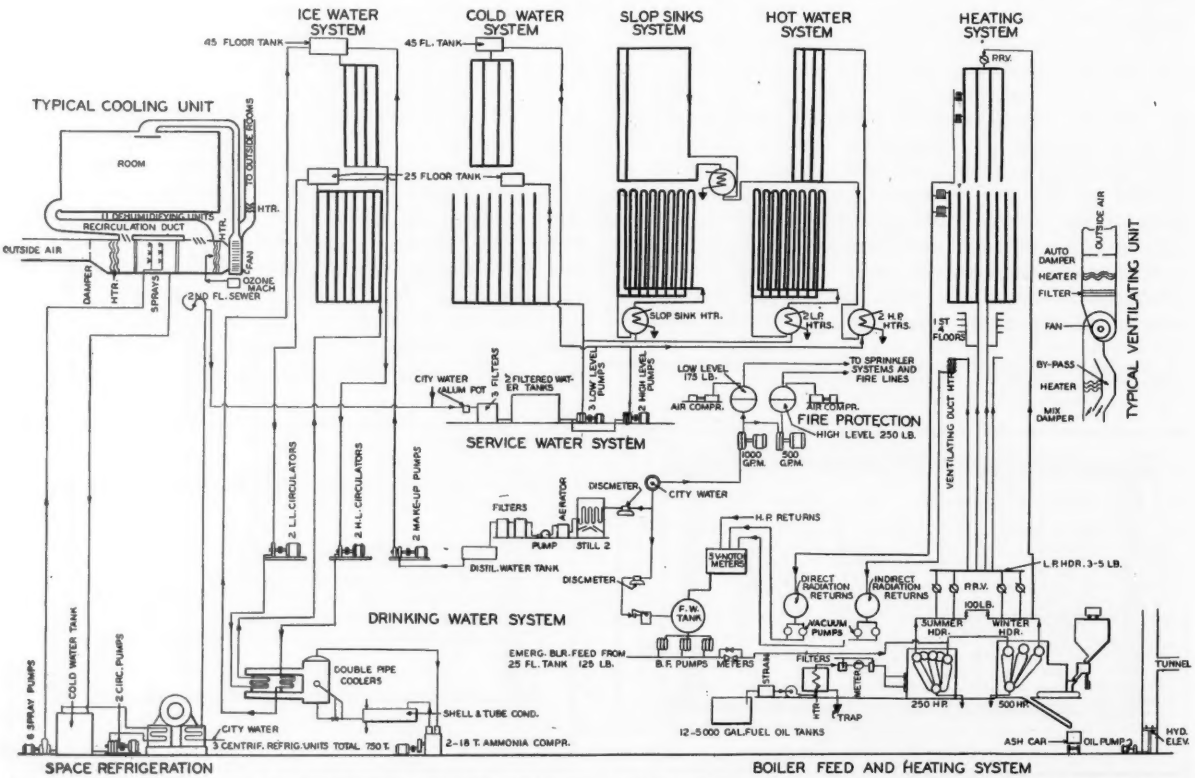


FIG. 6. DIAGRAMMATIC ARRANGEMENT OF THE HEATING AND WATER SYSTEMS. THE BUILDING IS SPLIT AT THE 25TH FLOOR, THE MAIN BUILDING SECTION FEEDING UPWARD, THE TOWER SECTION FEEDING DOWNWARD

Fig. 7. The Boiler Room contains two stoker fired and two oil fired boilers. The incinerator is shown in the foreground. Gas is used on the latter and can also be extended for use on the two small boilers

tem in 100 per cent operating condition has been provided. In a system such as this involving thousands of electrical contacts, relays, magnet coils, springs, etc., it is not enough to be able to locate trouble should it occur but faults must be anticipated and thereby prevented. The car terminal blocks for example are below the controller, near the floor, in full view and of easy access so that mechanics will make the routine tests which have been found so necessary. The junction boxes, also, are easy of access from the floor openings, being mounted underneath the car, at the door opening. Thus a man on top of the car can check the terminals in the hatch box with those of the car junction box with a man on the floor below.

Another new feature of this elevator system is the means provided for detecting and locating defective interlocks. Ordinarily, with hundreds of contacts in series this is a tedious procedure and involves manual testing of each contact. Under the direction of engineering department of the Field Estate, a high frequency fault locating system was developed which has proved exceedingly valuable. This involves a capacity bridge arrangement, employing a thermionic tube oscillator, whereby the capacity to the fault can be determined accurately in terms of distance from the pent house. A similar arrangement is used to detect burned out bulbs in the hall lanterns.

The shaft equipment was installed with unusual care, the rails being installed with the aid of surveying instruments. To ensure permanent accurate alignment specially machined, faced and ribbed side fish plates were provided at the joints.

Evans equalizers are installed on all hoist ropes on top of the car as well as compensating equalizers.

Heating System and Boilers

Insofar as the mechanical system is concerned the building is divided into two sections, the main building up to and including the 24th floor and the tower section from the 24th up to the 44th floor. Elevator pent houses and water storage tanks for the main building section are located on the set back roofs, in effect on the 25th floor level. The building is divided into high and low level systems at this point and, as there is no attic space between the 24th and 25th floors, mixed systems were adopted for the two levels. In general, the heating and water systems feed upward from the basement in the main building section and downward from the top floor in the tower section.

The heating system is of the two pipe vacuum type with the new National lightweight cast-iron radiators running about 1.75 lb. per square foot of surface. These radiators, located under the windows in flush mounted enclosures, are each equipped with Direct Control valves and designed so that humidifiers can be installed in the same enclosure. Each steam riser is equipped with a Johnson remotely controlled valve operated by push button from the engineer's office, giving complete control of the heating system from a central point.

The heating system is completely welded Byers and Reading wrought iron pipe being used for the low pressure system and Jones & Laughlin and Youngstown steel pipe in the high pressure system. Welded fittings where used were Midwest.

In addition to the direct radiation, there is con-

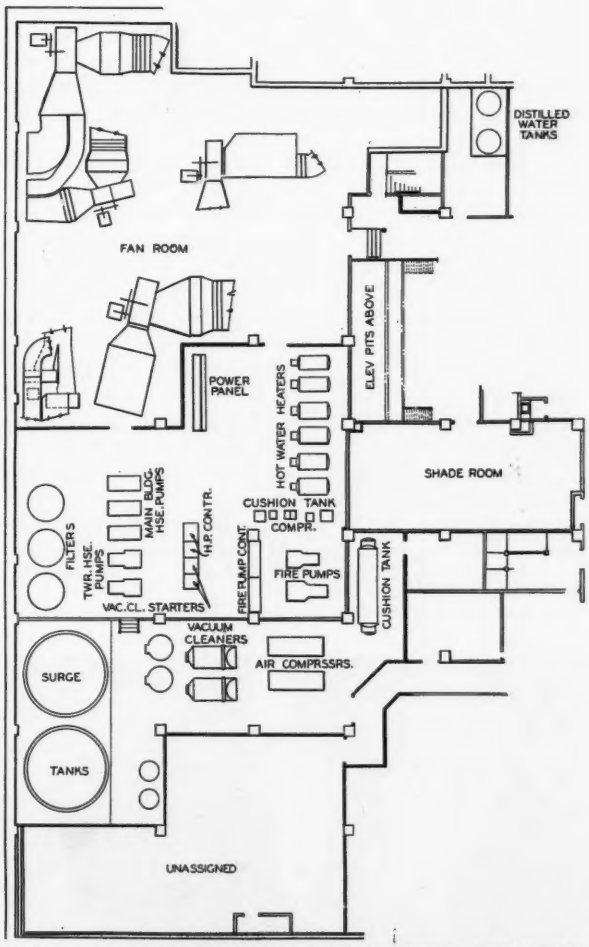


FIG. 8. PLAN OF THE SUB-BASEMENT WITH THE HEATERS, PUMPS, FILTERS AND SURGE TANK

siderable indirect heating incorporated in the ventilating and air conditioning systems. All parts of the building without outside exposure are ventilated, a typical ventilating unit being as shown at the right of Fig. 6. First there is an automatic damper interlocked with the fan starter so that the damper is open only when the fan is operating. Following this there are Vento tempering coils and an American self-cleaning air filter. Following the fan is a Vento reheater, with a bypass and Johnson mixing dampers, as shown in the sketch. There are 28 Buffalo supply and 28 Buffalo exhaust fans on this system.

In addition, the first four floors and basement are completely air conditioned by the Carrier system, using three centrifugal refrigerating units totaling 750 t. and 11 dehumidifying units. A typical unit is shown at the right hand side of Fig. 6. For ducts to outside rooms Aerofin booster heaters are installed to give additional heat control for these more exposed locations. Temperature is controlled throughout by Johnson Service regulators.

Water for the sprays is supplied from a refrigerated water storage by six Buffalo pumps and water from the sprays is returned to a baffled section of this same tank. Water in the tank is constantly circulated through the refrigeration units by one of two Buffalo pumps. Condenser water is taken direct from the city mains and discharged on the second floor of the building. From here it flows by gravity through International sand filters to surge tanks. Water that cannot be stored in these tanks flows to the sewer. In the winter time when the cooling units are not operating the surge tanks are supplied direct from the city mains.

Three fuels are available for steam making. Two 500-hp. Stirling boilers fired by B. & W. chain grate stokers are installed for cold weather service and two 250-hp. Stirling boilers set in a battery and fired by a Bethlehem Dahl oil burning system are intended for lighter steam loads. Gas is used on the incinerator and can be extended for use on the two smaller boilers when desired. In addition, central district heating steam is available at the property line and although no connection has been made as yet it is probable that this service will later be added for use in the summer months when steam is needed only for hot water.

Boilers are equipped with Bailey draft gages and boiler meters, Diamond soot blowers, Yarway blowoff valves, Ranarex CO_2 recorders, Lehnco damper regulators, Reliance low and high water alarm and Copes feedwater regulators. The stokers are driven by Crocker Wheeler motors through Reeves variable speed units and the fuel oil is pumped by Viking pumps direct connected to Crocker Wheeler motors. In general, motors throughout the building are of the Crocker Wheeler, ball bearing, grease lubricated type, operating at 208 v. a.c., the voltage between phases of the four wire system.

Fuel oil, received by truck, is stored in tanks below the sub-sub-basement level. Coal is received through the Chicago tunnel system, carried to the bunker level in a 12,000-lb. Pitt hydraulic elevator and dumped directly into the bunkers. Ash is dumped directly to the tunnel cars and hoisted to the tunnel level by the same elevator. Cars within the plant are handled by a Jeffrey electric locomotive operating from a 250 v.

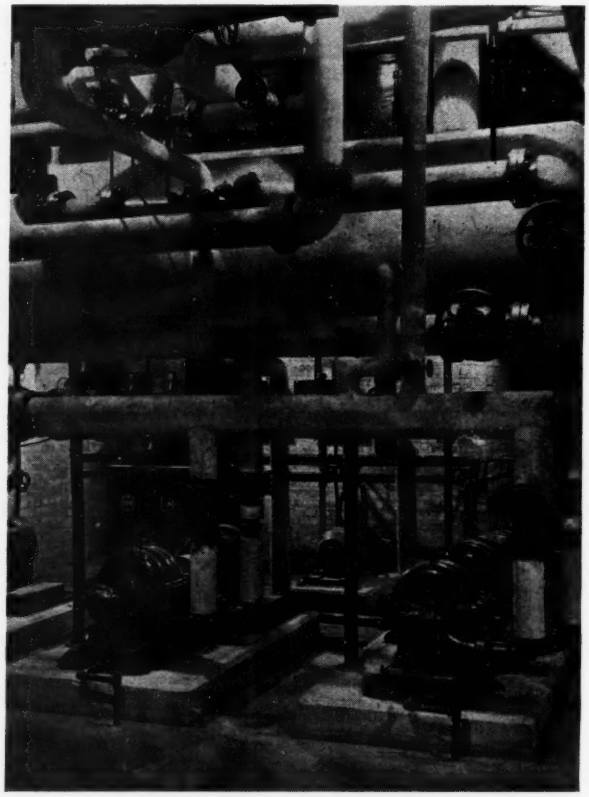


Fig. 11. Boiler feed pumps and heaters

d.c. trolley system. Power for this system is purchased direct from the tunnel company through a separate meter. This arrangement eliminates motor generator sets in the building and makes it possible for a tunnel locomotive to operate in the building if necessary.

Three Dayton Dowd, 3 stg., 2 in. centrifugal boiler feed pumps are installed, taking their suction from an overhead supply tank. Heating system returns are pumped to this tank, necessary makeup being added

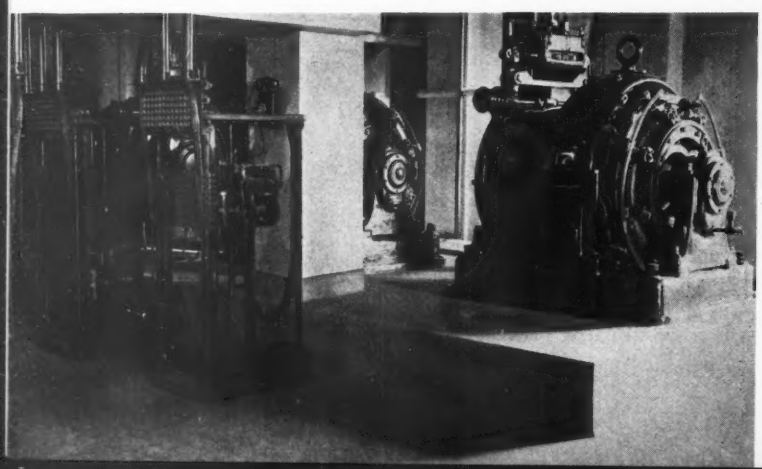


Fig. 9. Elevator machines in express elevator penthouse on 25th floor. This view shows one of the full wrap traction machines for the 800 ft. per min. express elevators and the control and micro leveling equipment

Fig. 10. The three large refrigerating units for air conditioning of basement and first four floors. These units have centrifugal compressors and total 750 tons refrigerating capacity. These operate in conjunction with 11 dehumidifying units

from the city supply system by a Boylston float control. In emergencies boilers can be fed by gravity from the 25th floor service tank. Feedwater is metered by a Bailey flowmeter with two primary elements, one for heavy and one for light load.

Direct radiation, indirect radiation and high pressure heater returns are used for boiler feedwater, each being kept separate until metered. The first two drain to separate receivers and are pumped by Nash vacuum pumps to an overhead Cochrane multiple V-notch meter which drains by gravity to the feedwater tank. High pressure drains return direct to the meter.

Steam Distribution

Steam generated at 100 lb. is reduced to 3 to 5 lb. for the heating system, the headers being sectionalized in such a way that in summer, with the steam load reduced to the hot water heaters, only the piping section in actual use is hot. Separate branches from the low pressure header supply the various building sections. Both indirect and direct radiation is supplied from the same low pressure header. This arrangement has been used successfully in several other buildings and the engineers feel that proper distribution of steam to the various heating sections is purely a matter of proper pipe size. Radiation in the tower section is supplied by a high pressure line to the top floor. Here a reducing valve supplies the low pressure system which feeds downward to the 25th floor where each riser is drained by a trap.

The cold or service water system is supplied from these surge or storage tanks by five Dayton Dowd centrifugals, three on the low level and two on the high level. The operation of these pumps is controlled from the 25th and top floor tank levels by Lehnco regulators actuating air operated diaphragm switches.

Drinking Water

Hot water is supplied by six Patterson-Kelley heaters, two on the low level, two on the high level, one on the slop sink and one on the restaurant system. No hot water circulating pumps are used, the heater taking its supply from the cold water pressure system and feeding it upward throughout the building with a return connection at the bottom. In the main building section where the feed is upward, each hot water riser has its return line in the same column. In the tower section the feed is downward from the top directly to the return header. The slop sink system on the main building is similar to the hot water system but the two tower slop sink risers are fed upward from the regulator high level hot water system through booster heaters.

Distilled and iced drinking water is supplied throughout the building through individual Jewell metered fountains for each tenant. Water for this unit is supplied by a 400 g.p.m. International Filter Co. system consisting of two stills, an aerating tank and two filters, the first a marble filter to remove the flat taste, the second an Hydrodarco unit, an activated carbon filter, used to remove organic taste and odor. Water from the aerating tank is pumped through the filters by a Westco pump to the distilled water tank.

From this tank the water is pumped to supply tanks on the 25th and top floors by one of the two makeup pumps. The 25th floor tank is float controlled, the top floor tank level is regulated by a Lehnco control on the pump starter. The water is cooled by two 18 t. Brunswick-Krochelle ammonia units, with a shell and tube condenser and a flooded double pipe cooler system. Drinking water is circulated continuously by pumps, downward from the top floor tank through the risers and through the coils in the lower section and from the coils upward through the risers to the 25th floor tank. All piping and parts coming in contact with drinking water is tin lined, and the pumps are all Westco, two makeup, two high level circulators and two low level circulators.

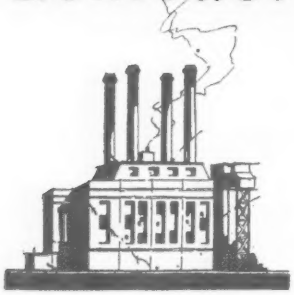
Fire System

Fire protection is provided by two Dean Hill motor driven fire pumps, one a 1000 g.p.m. on the low level taking its suction direct from the city mains, the other a 500 g.p.m. on the high level and taking its suction from the larger pump. A fire pressure tank, supplied with air by Worthington vertical compressors, floats on each line and maintains pressure on the sprinkler and fire system at all times. There are also two Gardner-Denver 10 by 12 in., 80-lb. single stage compressors for the control equipment throughout the building and two Spencer vacuum units for the building sweeper system. Sewage from the sub-basements is handled by two Shone ejectors.

The Field Building was designed and its construction superintended by Graham, Anderson, Probst and White, architects, with George A. Fuller as general building contractor. The mechanical and electrical systems were designed by the Engineering Department of the Marshall Field Estate working with the architects and various contractors. The electrical work was done by the A. S. Shulman Electric Co., Robert Gordon, Inc., were the heating contractors and the ventilating system was installed by Wolf Bros., all of Chicago.

In concluding this description we wish to extend credit to these firms and to the engineers of Marshall Field Estate for assistance rendered in supplying us with data for this article.

Combustion Control for Power Plants



Factors Involved in the Selection of the Combustion Control System to be Employed, the Location of Equipment, Motors Used, Care Needed and Economic Problems

By Gustaf A. Gaffert

CONTROL of combustion other than by manual means is a subject that usually comes up for discussion at some point in the course of design and construction of a power plant. Not many years ago a power generating plant was a necessary nuisance to many an industry, and relatively few instruments as an operating guide were provided. Today the situation is changed and an industrial generating plant, as well as a central station, must account to a critical management for the amount of power obtained from a given quantity of fuel and overhead wages.

Fundamentally, a successful combustion control system accomplishes the same results that a skilled operator could obtain by observing the variation of operating conditions on various gages, indicators and recorders, and making unerringly the correct adjustments each time. The most important variable is the fuel-air ratio. Means must be provided in any system for adjusting conditions to a desired value and, of course, to hold the boiler pressure at or near its design operating pressure. All other features are refinements or protective devices which are more or less important to each installation.

Pressure and Flow Responsive Devices

First to be considered is the criterion by which a system is usually operated. Whether the plant is large or small, a change in load means an increase or decrease in steam demand. A pressure responsive or flow responsive device then replaces the operator in creating a demand for more or less fuel and air by adjusting speeds and damper positions. A pressure responsive controller is really a flow indicator, since an increase in steam flow results in a higher pressure drop in a given section of piping. The range within which pressure should be maintained varies from 5 to 25 lb. as a rule, depending upon initial pressure.

When the steam demand is translated into fuel and air demand, the difference in available systems is apparent. Some are electrical and mechanical, and some are purely mechanical. There is a variety of fuels to deal with and consequently a variety of control equipment. In a stoker fired plant, stoker speed in the case of chain grate, or stoker stroke in the case of retort type stoker, must be changed by the operator or by a control system. If driven by a variable speed d. c. motor, the obvious thing is to vary the position of the rheostat on the motor. Even in an electrical control system, the impulse is finally mechanical which changes rheostat position.

Where a mechanical transmission gear is connected to a constant speed motor, the speed ratio can be readily varied by a positioning motor and linkage. In the case of pulverized coal firing there are the bin and unit systems to consider. Fuel rate control in the bin system usually resolves itself into a control of the speed of the screw feeder to an individual boiler. In the unit system where ball or hammer mills are employed, if the mills run at constant speed, the feeder speed is usually available as a variable. Speed is then varied mechanically through linkage connected to feeder motor, but it is far better controlled through direct speed variation of a variable speed motor. In case direct current is available, this is a relatively simple matter, and with an a. c. system, Ward-Leonard or similar equipment must be used.

Where the plant is located in the gas or oil producing districts and these fuels are used, special valves are customary to provide the graduated and regulated flow required. They are positioned from the master pressure responsive controller either mechanically or electrically through a positioning motor and linkage or directly through linkage. A by-pass must be provided so that, if the valve should stick in open or closed position manual regulation can be accomplished.

Essentials of Air Supply Control

Control of air supply goes simultaneously with control of fuel feed. Operation has established that a furnace should be operated on a balanced system of draft with a slight vacuum of from 0.1 to 0.2 in. of water. Most systems provide a furnace pressure regulator and operate through an electrical or mechanical system to position the blast damper and change speed in the more elaborate systems on the forced draft fan. The removal of products of combustion must be coördinated with fuel feed or boiler rating. In a very simple plant where there is no induced draft fan, this load falls upon the uptake stack and uptake damper.

Induced draft fans can be regulated by position ing a damper in the suction and by changing speed A popular motive element is the change in draft loss across some part of the boiler generating tubes with rating actuating through the medium of a differential regulator balanced either mechanically or electrically

as with a solenoid in the position damper motor circuit. The types of motors to be used for fan regulation must have a variable speed element. This becomes increasingly more important when the station capacity is large, since money can be saved in low speed operation at low ratings and better combustion control exercised.

Motors for Combustion Control

Something should be said about motors used in the case of combustion control. Direct current is more readily adaptable to the necessary variable speed element demanded. Many operators and designers, however, do not like to have too much d. c., if any, around a large a. c. plant, since it requires motor-generator sets and a certain extra amount of equipment. On the other hand, a. c. requires expensive speed control equipment where motor powers are large. Feeder motors are usually small, but fan motors are relatively large. The latter, if of slip ring or special adjustable speed design, are usually justifiable on a power saving basis at fractional loads and do allow closer regulation for an automatic combustion control system.

Consider a simple industrial plant where power is not the prime consideration. As the first cost of the plant is not large relatively, an expensive system of combustion control, even with marked savings, is not feasible. Usually the power cycle is simple and more often than not there is no induced draft fan. Assuming also that the forced draft fan is operated by a constant speed motor, a very simple control system, if any, should suffice. A steam pressure responsive element operating mechanically, probably through fluid and pilot valves to position the fuel feed device and forced draft fan damper, seems sufficient. Even if the labor employed is not highly skilled, this simple system can be readily kept in order under the watch of the chief engineer or plant superintendent.

Again where a small station is located in a sparsely settled district slowly developing a load, a control system deserves consideration. The plant design may be without curtain wall between boiler and turbine room —a modern tendency—and operators few. In such case, again a simplified inexpensive system may save money, or at any rate relieve the operators of too many duties.

Comparative Tests Show Savings

Since the large industrial plants and central power plants involve heavy investment, and therefore considerable fixed charges, the operating records are scrutinized closely. If the load is of a fluctuating character, automatic control will in some cases do a better job of following changing conditions than a conscientious operator can do. The difficulty usually is that savings are intangible since no data are available for the local conditions involved showing what can be done with and without automatic control. The closeness with which load demand and firing rate are adjusted by either method is intangible with good operators. The record of CO_2, and consequently stack losses with and without automatic control over a representative period of time, does give an idea of the possible fuel savings. When capitalized and set over against the cost of the system, with its necessary, competent and periodic ispection, more data should be available from which to draw some conclusions.

If an elaborate system is justified, there are several good mechanical-electrical and mechanical systems to consider. In any case the important parts of the system should be located where they can readily be inspected. In particular, great care must be taken to locate the CO_2 gas sampler at a representative point in the uptake and to get the analyzer close to the sampling point so that there will be a minimum time lag between sample and corrective control response. The same can be said about the position of the steam pressure or flow responsive controller, and the piping system should be carefully studied to obtain that location most typical of load change. In practically all cases, it is necessary to provide interlocks, as, for example, between the forced and induced draft fan motor circuits and fuel supply control and exhauster fans, to reduce hazards of explosion. All dampers should be carefully arranged or the motive system analyzed to see that they will remain open or shut as safety requires in case of failure of the control system.

Location of Control Mechanism

Centralization of all controls on one common board with operating gages and recorders in the case of a system of few controls, and on an entirely separate centralized board in the case of a more elaborate system, is advisable. Indicating instruments should be mounted near eye level, and hand levers and rheostats located at a convenient operating height. All non-operative parts, such as junction boxes, relays and mechanical shafts and sub-levers, are kept located compactly behind the main board in such a location as to allow easy access for inspection and repair.

Provision for manual control should also receive careful thought. Practically every installation has to be started manually and some systems of control do not function as effectively at very low ratings. Also, in the case of trouble, as operation must go on, quick electrical or mechanical disconnection for the respective control systems should be provided. The system should then be perfectly free to function without interference from the controls, and centralized grouping of control levers and motor switches on the gage board will facilitate operation.

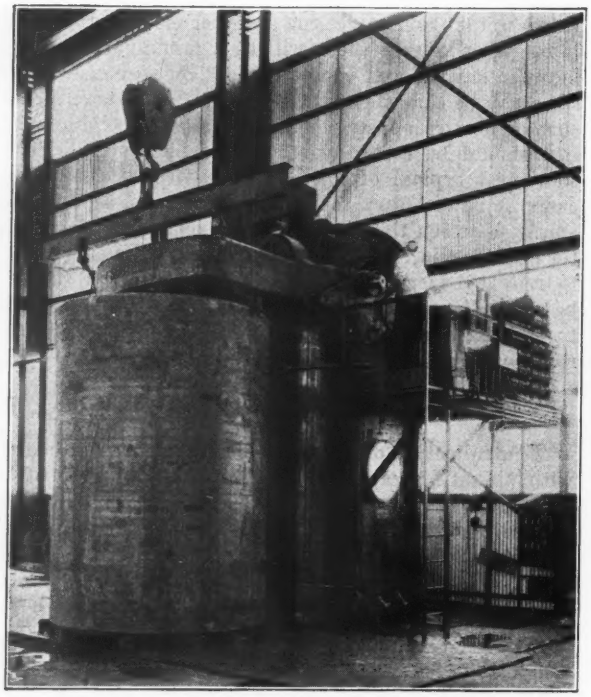
Factors Entering Into Selection of Equipment

In considering the mechanical and electrical systems, several questions, beyond the first cost of the one versus the other, must be raised and answered. It is necessary to determine the quality of regulation and ruggedness with which the design is constructed. Regarding quality of regulation, the possibility of overtravel and hunting due to lack of fineness of rheostatic control, friction, and a positive means of restoring a new equilibrium, should be considered. The question as to how the system will probably function with the class of skilled labor available has to be studied; also the question as to whether the growing complexity of the system is worth the price in terms of potential trouble and location of the source. Maintenance of responsiveness and low frictional resistance are also factors.

X-Raying 400,000 Feet *of*

Fabrication of Steel Headers and Penstocks for This Great Hydroelectric Development Effected in Plant Erected at the Site. Work Involves 45,000 T. of Steel Plate

By Robert G. Skerrett



Vertical Roll Plate Bender. The machine will handle steel plate from ⅜ to 2¾ in. thick

ASIDE FROM THE power to be developed from the water of the Colorado River by the construction of Boulder Dam, the really important object of the project is the flood control which it will provide. This flood control will be assured by the four-fold division of the control conduits which are now under construction and which are composed of headers and penstocks that are for the greater part of extraordinary dimensions. These conduits will carry water from the reservoir either to the hydro-electric units or to outlet valves that will return directly to the river, below the dam, such water as may not be needed to generate electricity. Instead of utilizing rock-driven tunnels, as is so frequently the practice at hydro-electric plants, the conduits at Boulder Dam are to be steel pipe of diameters of 30 ft., 25 ft., 13 ft., and 8½ ft. The turbines in the power house and the outlet valves will operate under heads ranging from 420 ft. to 590 ft.—depending upon the level of the water in the basin; and the water-hammer action, induced by the abrupt closing of any of the power or outlet valves, may attain a disruptive pressure as high as 300 lb. to the sq. in. These figures indicate broadly the service requirements that will be imposed upon the conduits.

The contract for the conduits was awarded the low bidder, the Babcock & Wilcox Co., on July 9. 1932, and the contract price was $10,908,000. Actual fabrication of pipe sections was begun a year ago, after the company had erected and equipped a field fabricating plant, at Bechtel, Nevada, at a point about a mile and a half west of Black Canyon. It was necessary to provide means for constructing the conduits close to the dam because their great sizes make it impossible to fabricate them at some industrial center and transport them by rail. The plates are being supplied by the Gary, Indiana, mills of the Illinois Steel Co.

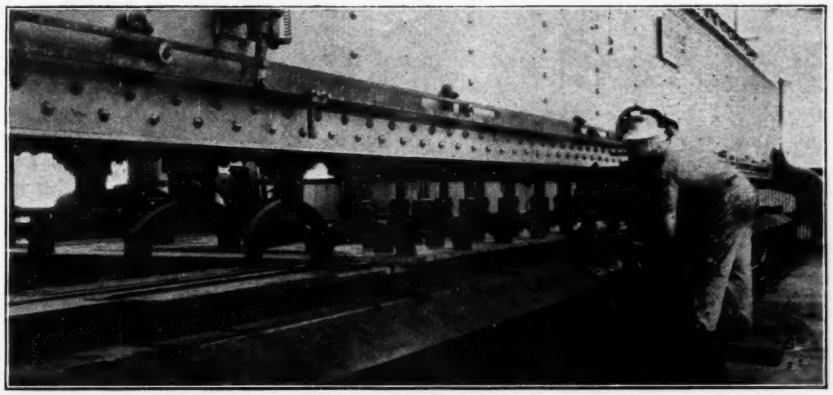
The principal characteristics of the various pipe sections are as follows:

Length Feet	Diameter Feet	Maximum Plate Thickness Inches
4700	30	$1\frac{1}{16}$—$2\frac{3}{4}$
1900	25	$1\frac{5}{8}$—$2\frac{5}{16}$
5600	13	$\frac{5}{16}$—$1\frac{5}{16}$
2300	8½	$\frac{5}{8}$— $\frac{7}{8}$

All told, 45,000 t. of steel plate will be used in fabricating the 14,500 linear feet of conduits.

The main shop at Bechtel is of a typically modern steel-framed type, covered with galvanized sheet steel and generously provided with glazed steel sash to afford plenty of natural light within. The structure is 520 ft. long, 85 ft. wide, and with a clearance of 55 ft. between the floor and the chords of the roof trusses. Heavy supporting steel columns, on 25-ft. centers, provide essential support on each long side of the building for the roof and for three traveling cranes, each of which has a span of 85 ft. and a lifting capacity of 75 t. All plates are rolled to shape cold by a set of vertical rolls, 12½ ft. high, operated by a 150-hp. motor. The two power rolls are 32 in. in diameter, and the single adjustable guide roll is 40 in. in diameter. The latter is mounted upon a roller thrust bearing, and a screw-down, motor-driven mechanism moves the roll toward or away from the power rolls, according to the thickness of the plate being handled and the prescribed curvature. Plates that are to form conical sections and the bull-dozing of the plate edges preparatory to rolling are handled by two 1500-t. presses that operate as a unit. The presses are actuated by oil at a pressure of 2000 lb. per sq. in.—the pressure being developed by rotary pumps. Plate edges are machined to form narrow grooves when

# of Welding *at* Boulder Dam



The giant planer showing the set-up of the plate and the tool holders

brought together for welding. The edges are beveled for this purpose by a planer of exceptional size and design that has a bed 40 ft. long on which plates are held rigidly by a series of clamps actuated by pneumatic plungers. The planer is driven by a 40-hp. motor. The shop also has a horizontal boring machine of such size and spread that it can machine the ends of pipe sections of the largest diameters.

Under the contract the Government specified that the plates for the conduits should be of high tensile steel and that all erection-sections should be assembled by the fusion welding of both longitudinal and girth seams.

The automatic fusion-welding machines used are electrically operated. The metal rods or electrodes are fed into the flame of the arc at an exact speed; and it is not necessary to stop the machine to replace a nearly consumed rod—a new rod being attached to the rod already in the machine. The electrodes are coated with a special flux developed by the Babcock & Wilcox Co. This flux melts with the rod and, being lighter than the steel of the rod, forms a protecting film over the molten metal, thus excluding the atmosphere. When the overlying film of flux solidifies, it is easily fractured and brushed or blown aside, and the underlying metal is then found bright and clean and in a perfect condition to receive the next layer. When a seam has been filled from the outside, the backing is removed and the root or bottom of the weld is examined for visible imperfections, and, if such exist, they are chipped out until bright and sound metal is exposed. The seam is then rotated to the lowest point, and the welding machine is placed inside the pipe to give the inside of the seam the necessary finish. During welding, sections are supported on rollers that facilitate the rotation of the sections, and it is while a section is being rotated that a girth seam is welded. In that case, the welding machine remains stationary while the pipe is rotated at a uniform speed.

The first of the non-destructive tests of the welding is made with the X-ray apparatus developed particularly for the purpose through the collaboration of the contractor and the General Electric Co. The X-ray tubes used are of unprecedented dimensions and power; their rated voltage is 325,000. The generated rays can penetrate the thickest of the plates used in conduits and produce a nicely focused radiographic record by an exposure of 20 seconds. The films thus obtained disclose the presence of blowholes, slag inclusions, or fractures anywhere within the mass of a weld, and before the work at Bechtel is finished, about 400,000 linear feet of welding will thus be examined. Wherever defects are found, the weld metal is cut out and fresh metal deposited, after which the area is once more X-rayed. After all the welding of an erection-section has thus been proved satisfactory, the section is moved to a great stress-relieving furnace, adjoining the shop, to relieve the section of any stresses set up either in the plates during bending or in the seams during welding.

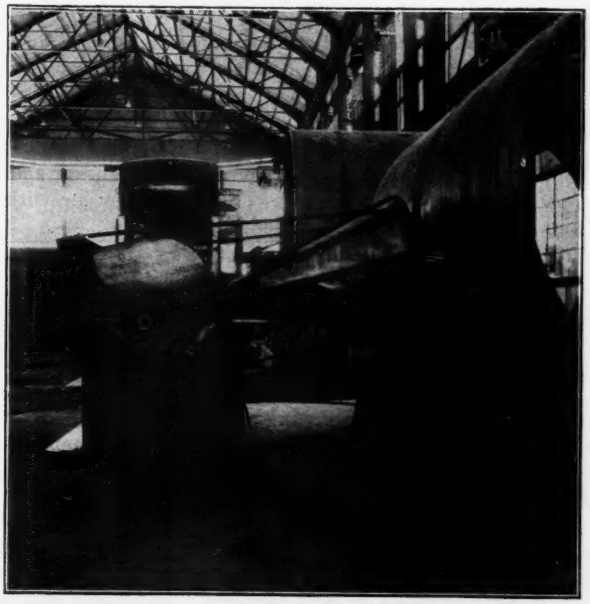


FIG. 3. X-RAY MACHINE SET UP FOR X-RAY INSPECTION OF GIRTH SEAM IN 8½-FT. PIPE.

Figuring A New Winding *for an* Old Motor

By C. C. HERMANN

IT IS A RELATIVELY simple matter to duplicate the winding of a given electric motor. If the motor comes into the plant with the old winding in the slots and the connections still intact all that is necessary is to take note of the connections, determine the pitch of the coils, coils per pole phase group, number of turns of wire per coil, size of wire used, size of coil with regard to unformed length and such information from the name plate of the motor as speed, from which is obtained the number of poles, the voltage and cycles of the current for which the winding was designed. With this information and the knowledge of motor winding a new winding may be placed in the motor which will function just as well as the original winding.

Suppose, however, that the motor is brought into the shop with the old winding removed. In that case much of the data necessary for the intelligent winding of the motor is missing. This missing data must be supplied. The name plate data, of course, is available such as the required horsepower at the given voltage, speed, phases and frequency. This data together with the following general knowledge is at hand.

1. The motor must carry its rated load without drawing from the circuit an abnormal amount of electric energy. In other words it must operate efficiently and economically.

2. The motor must carry its rated load under normal conditions without resulting in abnormal temperature conditions in the winding.

3. The power factor of the motor must be maintained within reasonable limits. As a new motor it had certain power factor characteristics and this must be duplicated as nearly as possible.

4. Proper mechanical clearance must be maintained between the rotor and stator in order to maintain maximum bearing life.

5. It must have a momentary overload capacity of from 1½ to two times full load torque without stalling, or at least it must come up to the standard established for the particular type of motor considered.

6. The motor must operate with the minimum amount of noise due to magnetism and windings.

All these requirements must be properly considered and their values recognized before one is ready to construct a winding formula which will produce a motor that will go into service and give satisfactory results. From the design standpoint there are many other considerations to take into account, however, it is unnecessary to go into this as the original designer of the machine has established the core thickness, the slot depth and width and other vital points of the motor. We have a motor stator which is ready for the new winding and it is up to someone to calculate the winding. To do this certain characteristics must be understood and taken into account in designing the new winding. Some of these points are as follows:

1. Taking as a basis a given winding any increase in the number of turns per coil will lower the starting torque of the motor. The starting current drawn by the motor would be lowered and the power factor higher. Copper losses for the motor would be higher and iron losses lower. If the ratio of the copper losses of the old winding to the new winding showed the same rate as the ratio of the iron losses of the new winding to the old winding the efficiency would be similar in the motor with the new winding as with the old winding, however, if this rate increased; that is, if the copper losses increased at a higher rate than the iron losses decreased the efficiency of the motor would be higher and with the reverse condition the efficiency would be lower. To decrease the number of turns per coil reverses the above conditions.

2. Increasing the number of turns per coil has the same effect as operating the motor on a circuit with a lowered voltage from that specified by the name plate or for which the motor was originally wound. Obviously a given motor has very definite limits on the number of turns of a given size of wire. The limit is the maximum number of turns which can be placed down in the slot, the size of the wire as required to transmit the current or as generally considered the cross section of copper, and the motor requirement relative to efficiency and power factor.

A concrete example will, perhaps, serve to make the problem easier to understand as well as more interesting. For our purpose we will assume that we are to wind a motor for 7½ hp. at 1200 r.p.m., 60 cycles for 440 v. The stator core bore of the motor is 8.5 in. and its axial length is 3.5 in.

In the formula for horsepower we encounter the output efficiency factor K. This factor depends for its value upon the pole pitch and the number of poles in the winding and can be obtained from any standard handbook on the subject. For the example at hand the pole pitch is 8.5×3.1416 divided by $6 = 4.45$ in. and $K = 0.000025$. Then hp. $= 0.000025 \times 8.5^2 \times 3.5 \times 1200 = 7.22$.

Some consideration must be given to the iron between the bottom of the slots and the outside periphery of the core. A few calculations will readily show that the greater the number of poles the motor has the less iron is required, that is, the higher speed used the less the weight of the machine which holds just as true with electric motors as with other machines. To determine the iron cross section we must calculate the density of the magnetic flux and see that this does not exceed the usual limits of 100,000 magnetic lines per square inch cross section of iron between the bottom of the slots and the outside periphery. Again the magnetic flux depends upon the number of turns of wire in the coils and an attempt is made to regulate the number of turns of wire so that the number will go into the slot space allowed. If the number is so large that the slot will not accommodate as many turns it merely means that the motor is overrated and we must start over again with a lower rating. Again by dropping the number of turns of wire in order to accommodate the slot room will result in increasing the magnetic flux above the allowable limit. Thus we see that the number of conductors per slot and the magnetic lines of force are tied together. This is because the conductors which are in series in the winding, when cut by the magnetic field, must generate a counter e.m.f. almost equal to the line of voltage.

The flux per pole =

$$\frac{45{,}000{,}000 \times \text{volts per phase}}{\text{cycles} \times \text{conductors per phase} \times K_1 \times K_2}$$

Volts per phase for the delta connected 3 phase winding is equal to the line volts or 440 whereas in the star connected winding this value is line volts ÷ 1.73 or 254.3 v. Our motor is 3 phase and we will assume a star connection; therefore the volts per phase is 254.

The conductors per phase = wires per slot which are in series × number of slots ÷ number of phases.

K_1 is the distribution factor and may be obtained from any standard electrical handbook. For the motor in question this factor may be taken as 0.955.

K_2 is the chord factor and depends on the pitch of the coil. This value is the sine of one-half of the electrical angle spanned by the coil or

$$\frac{(\text{No. of slots per pole})^2 - 2\,(\text{No. of slots dropped})^2}{(\text{No. of slots per pole})^2}$$

Since this motor has 54 slots and the full pitch would be 1 and 10, the winding would be made with a pitch of 1 and 8. Therefore the number of slots dropped would be 2. Inserting these values in the formula given above we have the resulting value of K_2 as follows:

$$\frac{9^2 - 2 \times 2^2}{9^2} = 0.95$$

The flux per pole formula can now be used, inserting the values found above.

$$\text{Flux per pole} = \frac{45{,}000{,}000 \times 254}{60 \times 504 \times 0.955 \times 0.95} = 416{,}621$$

The outside diameter of the stator core is 13 in., the slot depth 1 3/16 in., and the slot width 5/16 in. We now have sufficient data to calculate the density of the magnetic flux in the iron below the slot and in the teeth of the core.

The diameter to the middle of the slots is 8.5 in. plus 1.1875 in. or 9.6875 in. The circumference of this circle would be 9.6875×3.1416 or 30.43425 in. and the slot pitch is this circumference divided by the number of slots or 0.5636 in. The thickness of the teeth is therefore $0.5636 - 0.3125 = 0.2511$ in.

The cross section of the tooth is, therefore, $0.2511 \times 3.5 = 0.8788$ sq. in. The cross section of the core below the slot is $3.5 \times 0.9375 = 3.28$ sq. in.

Now the magnetic lines of flux in the iron below the slot is 416,621 divided by 3.28×2 or 63,509. Multiplying the area by 2 before dividing the magnetic flux per pole by the area is necessary due to the fact that the flux divides part going one way and part going the other way in the iron.

The density of the flux in the teeth cross section is likewise $0.8788 \times 8 \times 0.636 = 4.56$ sq. in. divided into $\frac{416{,}621}{2} = 45{,}682$. Since the density is well under 100,000 lines of force, the winding is permissible.

We assumed the number of conductors per phase above at 504. We can now check this figure to see if it is within reason by use of the following formula. Conductors per phase =

$$\frac{45{,}000{,}000 \times 254}{60 \times 3.28 \times 100{,}000 \times 0.955 \times 0.95} = 645$$

Then total conductors would be $3 \times 645 = 1935$. Conductors per slot $1935 \div 54 = 35.8$ say 36 or the conductors per coil would be 18.

If we assume the efficiency of the motor at 85 per cent and the power factor at 80 per cent, the full load current of the motor would be 7.5×746 divided by $1.73 \times 440 \times 0.85 \times 0.80$ or 10.8 amp. The current per coil would be $10.8 \div 1.73$ or 6.24 amperes. Since the current carrying capacity of copper wire is in the ratio of 750 cm. per ampere, the cross section of the wire must be 750×6.24 or 4680 cm. We suspect that this winding must be two parallel; therefore it will require two No. 16 gage wires.

Checking our slot room for this wire, we find that our first figure of 14 turns of two parallel number 16 wire just fills the slot. Furthermore we would connect this motor series star because if we were to connect it series delta we would have 504×1.73 or 872 conductors per phase or 24.2 turns per coil as compared with 14 turns per coil selected. The cross section of the wire would be the same; therefore, the 96 strands of wire could not be placed down in the slots.

Power Station Building Costs

Committee of the E.E.I. Reports Possible Investment Saving of Outdoor Plants

WITH THE INCREASE in capacity of steam generating units, the development of interconnection between stations and systems, and the marked improvement in reliability of equipment, there has followed a definite trend toward simplification of layout to eliminate complicated interconnection of units and unnecessary duplication of auxiliaries.

This trend reflects the transfer of attention of designers from too sharp focusing on increased heat economy to the now more promising savings in reduced investment cost. To illustrate the significance of investment savings, the following table expresses a comparison between increases in initial cost equivalent to reductions in heat rate.

In comparison with a 14,000 B.t.u. per kw-hr. station costing $100 per kilowatt of installed capacity operating at 40 per cent capacity use with $4 per ton coal and assuming 12½ per cent fixed charge rate, increased initial costs, to be justified, will require the indicated lower heat rates:

Cost per kw...	$100	$101	$110	$120	$155
Heat Rate	14,000	13,750	11,500	9,000	0

This table shows that a 1 per cent increase in investment must result in approximately a 2 per cent reduction in heat rate in order to be justified under the given conditions.

It is the belief of this Committee that building costs can be reduced materially without too great sacrifice of pleasing appearance and none at all of fitness or adequacy for the real purpose of the plant.

Costs of Superstructure

A review of 15 power stations on which construction work dates from 1922 to 1933 shows an average of 14 per cent of the total plant cost chargeable to superstructure. A variation in this figure is noted among the plants of from 11 per cent to 18 per cent.

Selecting three of the more recently installed of these plants as representative of present day construction, it is found that exterior walls represent from 15 to 35 per cent of the total cost of superstructure. An average figure of 25 per cent would then imply that external walls accounted for something like 3 or 4 per cent of the total station cost. The steel frame represents another 25 per cent of superstructure cost. The remaining 50 per cent of the superstructure cost is accounted for by floors, roof, stairs, walkways, interior partitions, service equipment and miscellaneous expense.

In the cost of hydro-electric developments, normally greater per kilowatt than for steam plants, the building structure usually represents a very much smaller percentage of the total initial investment. In one recent installation the superstructure amounts to about 4 per cent of the total.

Many look upon the outdoor plant as a way of saving 10 per cent or more of the total plant cost, assuming a saving nearly equal to the cost of superstructure of present plants. Those who have made a study of the problem realize that the savings, while such as to warrant careful consideration, cannot be expected to approach this value.

The Philadelphia Electric Co. and the affiliated companies of the New York Edison System have given consideration to outdoor construction for large steam plants. These studies have determined in detail the relative cost of a completely outdoor type plant compared to similar equipment housed in inexpensive, factory type, medium grade common brick building. In the former case the cost difference is estimated at 1 per cent of the total station cost and in the latter approximately 3 per cent.

Since the only sound justification for outdoor construction is reduced expense, it remains to be determined if such differences will outweigh the recognized disadvantages from the standpoint of operation and maintenance. These studies indicate clearly that simplification of layout and architecture may be expected to accomplish practically as much reduction in cost as the outdoor station of extreme type.

A similar study of a water power development concluded that an existing housed plant could have been constructed only about one-half per cent cheaper had outdoor construction been undertaken. This figure is probably not representative of more favorable conditions existing at other locations.

Construction

Two semi-outdoor fuel burning plants and several hydro-electric plants are now in operation under varied climatic conditions. The Schenectady installation of the General Electric Co. has been constructed with no structure around the mercury turbine and only a closely fitting shell housing the boiler equipment. The auxiliaries are housed in a simple low structure which also provides office and service space. The exterior steel work of the building was designed to support all equipment and floor loads and then enclosed with pressed steel pilasters and facias to form a complete building exterior when filled in with metal sash construction. Interior partitions are also of light metal construction.

The Central Arizona plant, located near Phoenix, Arizona, where the climate is favorable to outdoor operation, is constructed with a housed turbine room, but the boiler room is open on the side facing the turbine enclosure and away from the direction of prevailing winds. The walls are built of expanded metal covered with four coats of gunite to a total thickness of one and one-half inches. The roof construction is corrugated metal decking with two layers of insulating lumber and a built-up felt roofing.

These two fuel burning plants, subject to widely divergent climatic conditions, have demonstrated the operating practicability of outdoor or semi-outdoor construction at least for the particular circumstances surrounding these installations.

Selection of Equipment for Economy

PART II.* Procedure in the Selection of Equipment to Provide Either Additional Capacity or a New Service of a Kind that Is Conducive to Economy

By
Linn Helander

SELECTING particular equipment to replace existing equipment after obsolenscence has been proved, is identical with the procedure of selecting equipment to provide a new service or an addition to capacity and divides into three problems:

(a) The problem of determining for each type or make of equipment available, that particular design which meets requirements the best. This problem will be designated hereinafter as problem (a).

(b) The problem of selecting from among the best designs of the several types or makes available, that particular design which meets requirements the best. This problem will be designated hereinafter as problem (b).

(c) The problem of determining whether or not the installation of this best of all designs available is justified on economic grounds. This problem will be designated hereinafter as problem (c).

Problem (a) falls usually to the lot of the equipment manufacturer; problem (c) usually to the lot of the purchaser; problem (b) sometimes to the lot of the manufacturer, perhaps more frequently to the lot of the purchaser. As an illustration, in preparing bids on air heaters, each manufacturer must determine as well as he can that particular design of his make that meets the customer's requirements the best. The purchaser then selects from among the various makes submitted to him that one which shows promise of effecting the greatest net economy in the operation of his plant. He next makes an investigation to determine whether or not the installation of the equipment thus selected is justified economically.

*Part I of this series dealt with obsolescence and was published in the June issue. A correction should be noted in Formula I and II of Table I, p. 272, where r the rate of interest should be used as a fraction and not as a percentage.

Most Economical Equipment

In this article, only the problem of selecting equipment which either has no effect on capacity or an effect that is specifically defined will be considered. For that case, that equipment is the best selection from the point of view of economy which makes:

(1) operating charges plus capital charges, evaluated for the plant as a whole, a minimum (see Fig. 5) or

(2) the decrease in operating charges minus the increase in capital charges a maximum (see Fig. 6), or

(3) the increase in operating charges plus the increase in capital charges a minimum (see Fig. 7).

Problems (a) and (b), as outlined, may be solved by making use of whichever of the above statements is the most convenient to employ, or by making use of some satisfactory corollary. One such corollary, which may be used to advantage occasionally in solving problem (a), is that the most advantageous magnitude assignable to any design factor, such for example as size, is that magnitude, a small increment of which will add the same amount to capital charges that it deducts from operating charges (see Fig. 8).

The first steps in selecting equipment for economy, that is, in solving problems (a), (b), and (c) are to

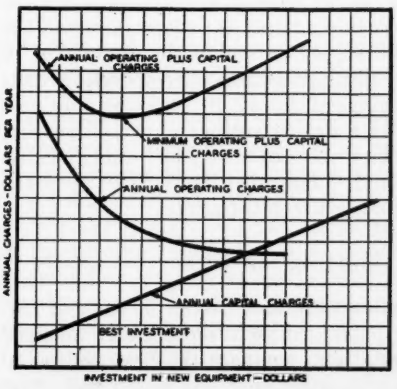


FIG. 5. THAT EQUIPMENT IS MOST ECONOMICAL WHICH MAKES OPERATING CHARGES PLUS CAPITAL CHARGES, EVALUATED FOR THE ENTIRE PLANT, A MINIMUM

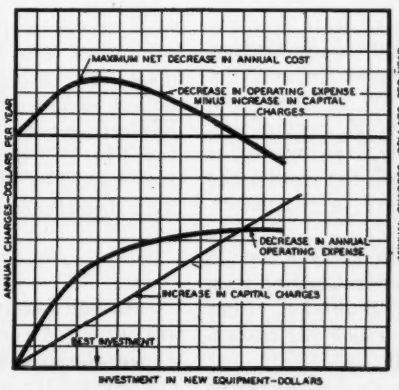

MAXIMUM NET DECREASE IN ANNUAL COST
DECREASE IN OPERATING EXPENSE MINUS INCREASE IN CAPITAL CHARGES
DECREASE IN ANNUAL OPERATING EXPENSE
INCREASE IN CAPITAL CHARGES
BEST INVESTMENT
ANNUAL CHARGES-DOLLARS PER YEAR
INVESTMENT IN NEW EQUIPMENT—DOLLARS

FIG. 6. THAT EQUIPMENT IS BEST WHICH MAKES THE DECREASE IN OPERATING EXPENSES MINUS THE INCREASE IN CAPITAL CHARGES A MAXIMUM

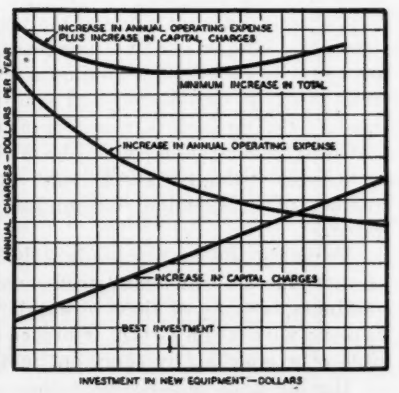

INCREASE IN ANNUAL OPERATING EXPENSE PLUS INCREASE IN CAPITAL CHARGES
MINIMUM INCREASE IN TOTAL
INCREASE IN ANNUAL OPERATING EXPENSE
INCREASE IN CAPITAL CHARGES
BEST INVESTMENT
ANNUAL CHARGES-DOLLARS PER YEAR
INVESTMENT IN NEW EQUIPMENT—DOLLARS

FIG. 7. WHEN THE ADDITION OF NEW EQUIPMENT INCREASES CHARGES, THAT EQUIPMENT IS MOST ECONOMICAL THAT MAKES THE INCREASE IN CHARGES A MINIMUM

define specifically the conditions under which the equipment to be selected will operate over the period of its expected useful life, fix the rate at which capital charges (interest, taxes, insurance, and depreciation) will be levied, and determine the cost of labor and of products to be consumed such as fuel, power and water. Typical load or output curves when available, otherwise capacity and load factors, should be obtained. In addition, unusual operating conditions of a nature that may influence the design or size of the equipment selected should be clearly specified. The latter is important, for the consideration of typical conditions alone may lead to a form of design inadequate to meet load demands under unusual operating conditions.

Having established the precise operating and cost data fixed by service conditions, the next step is to solve problem (a), that of determining for each type or make of equipment available that particular design which

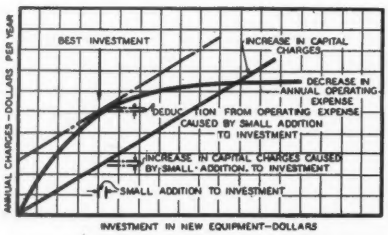
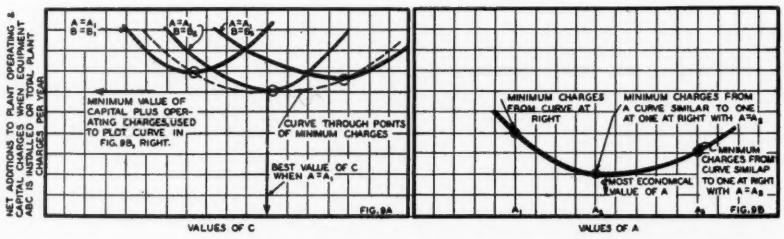

ANNUAL CHARGES—DOLLARS PER YEAR
BEST INVESTMENT
INCREASE IN CAPITAL CHARGES
DECREASE IN ANNUAL OPERATING EXPENSE
DEDUCTION FROM OPERATING EXPENSE CAUSED BY SMALL ADDITION TO INVESTMENT
INCREASE IN CAPITAL CHARGES CAUSED BY SMALL ADDITION TO INVESTMENT
SMALL ADDITION TO INVESTMENT
INVESTMENT IN NEW EQUIPMENT—DOLLARS

FIG. 8. THAT INVESTMENT IS BEST WHICH IS SO CHOSEN THAT ANY MINUTE ADDITION TO IT ADDS TO CAPITAL CHARGES THE SAME AMOUNT THAT IT DEDUCTS FROM OPERATING CHARGES. THIS OCCURS WHERE A LINE (OR CURVE) DRAWN PARALLEL TO THE LINE (OR CURVE) SHOWING THE INCREASE IN CAPITAL CHARGES BECOMES TANGENT TO THE CURVE SHOWING THE DECREASE IN ANNUAL OPERATING EXPENSE PLOTTED TO THE SAME BASE


NET ADDITIONS TO PLANT OPERATING & CAPITAL CHARGES WHEN EQUIPMENT ARE INSTALLED OR TOTAL PLANT CHARGES PER YEAR
A=A1 B=B1
A=A2 B=B2
A=A3 B=B3
MINIMUM VALUE OF CAPITAL PLUS OPERATING CHARGES, USED TO PLOT CURVE IN FIG. 9B, RIGHT.
CURVE THROUGH POINTS OF MINIMUM CHARGES
BEST VALUE OF C WHEN A=A1
FIG. 9A
VALUES OF C
MINIMUM CHARGES FROM CURVE AT RIGHT
MINIMUM CHARGES FROM A CURVE SIMILAR TO ONE AT ONE AT RIGHT WITH A=A3
MINIMUM CHARGES FROM CURVE SIMILAR TO ONE AT RIGHT WITH A=A2
MOST ECONOMICAL VALUE OF A
FIG. 9B
VALUES OF A

FIGS. 9A AND B. PLOT OF NET ADDITIONS TO PLANT CHARGES OR TOTAL PLANT CHARGES, DEPENDING UPON MANNER OF PLOTTING ADOPTED, SHOWING HOW VALUE OF ONE OF THREE INDEPENDENT DESIGN FACTORS IS ESTABLISHED

For a case involving three independent design factors, A, B and C, Fig. 9A shows net additions to annual charges, or total annual charges, when A has the value A, and B and C are varied. Through the minimum value of charges associated with each of the values of B, a curve is drawn as shown. The minimum value of charges read from this curve becomes a point on the curves in Fig. 9B. Other points for the curve in Fig. 9B are similarly obtained employing values of A equal to A_2, A_3, etc. The heat value of A is that which makes charges read from the curve of Fig. 9B a minimum

from the point of view of economy is the best. Now it can be demonstrated readily that the amount of work involved in solving this problem varies geometrically with the number of independent design factors to be investigated.

Thus if one design factor, for example size, is to be investigated, a minimum of three different designs each employing a different value of the factor must be established and studied; if two independent design factors, are to be investigated, a minimum of nine different designs must be established and studied; if three independent design factors, a minimum of 27 designs, etc. Obviously, every effort should be made to reduce as far as possible without casting doubt upon the results the number of independent design factors to be investigated.

Probably the best procedure is to make a list of all those factors which may need consideration and then eliminate as many of these as can be eliminated, either as being without important influence or as being susceptible of evaluation by short cut methods.

Having done this, the next step is to determine the best value of each of the remaining design factors. Graphical methods are usually employed here, although in some cases mathematical formulas can be developed which give direct solutions. To illustrate the graphical method, we shall assume that three independent design factors; A, B, and C, are to be investigated. Values of A_1, A_2, A_3, etc., will be assigned to A; values of B_1, B_2, B_3, etc., to B, and values of C_1, C_2, C_3, etc., to C. Then for the combinations A_1B_1C; A_1B_2C; and A_1B_3C, where C is given the values C_1, C_2, C_3, etc., combined capital and operating charges, deducting credits for economies to be effected by the equipment when installed, may be estimated and plotted against values of C as a base (see Fig. 9A); or if preferred, the combined capital and operating charges against the plant in which the equipment is to be installed may be evaluated, assuming the equipment in place, for each of the combinations.

If the first method is employed, the net charges may be negative, in which case they are plotted usually as net savings that will be effected by the installation of the equipment; otherwise they are plotted as net additions to be made to charges. If the resultant curves show savings, maximum values, if they show charges, minimum values are replotted against a suitable base, such as values of C. From the curve thus obtained may be determined, depending upon the procedure followed, either minimum additions to charges with A assigned a value A_1, or maximum predicted savings, or minimum total charges applicable against the plant in which the equipment is to be placed assuming the equipment in place. Repeating this procedure, corresponding data with A assigned values of A_2, A_3, etc., may be obtained. Replotting these data against values of A as the base, (see Fig. 9B), the best value of A may be found directly. Best values of B and C may then be derived from the data developed during the calculations.

Comparison of Types

Having determined the best design of each of several types of equipment, using the procedure outlined above, the next step is to compare the best designs of the several types and select that one which will effect the greatest net savings or add least to the total cost (including capital charges) of operating the plant in which it is to be installed.

To illustrate this step, let the following problem

be considered. Three types of equipment, A, B, and C, are available for a given service. The best design of type A is A_1; of type B, B_1, and of type C, C_1. Design A_1 costs initially \$1000, B_1 \$1500, and C_1, \$500. In case I, the net average addition to plant operating charges evaluated for the life of the equipment is \$200 per year when design A_1 is installed, \$150 per year when design B_1 is installed, and \$220 per year when design C_1 is installed. In case II, net average savings in operating expense are \$300 per year when design A_1 is installed, \$500 per year when design B_1 is installed, and \$200 per year when design C_1 is installed. Assuming that capital charges are 15 per cent of the initial cost, what equipment should be selected in each case? The solutions are worked out in the following tabulation:

Design	Case I			Case II		
	A_1	B_1	C_1	A_1	B_1	C_1
Initial cost of equipment - Dollars	1000	1500	800	1000	1500	800
Annual capital charges against equipment - Dollars per year	150	225	120	150	225	120
Average annual addition to operating charges - Dollars per year	200	150	220			
Total net increase in average annual charges - Dollars per year	350	375	340			
Design selected			C_1			
Average annual savings in operating expense - Dollars per year				300	500	200
Net annual savings - Dollars per year				150	275	80
Equipment selected					B_1	

Problem (C), that of determining whether or not installation of the best available equipment is justified, is sometimes solved automatically by solving problems (a) and (b); but usually not, since certain elements of cost common to all designs may be omitted in solving those problems. Thus erection costs or added building costs may be the same for all designs and so ignored in solving problems (a) and (b). In solving problem (c), one has only to evaluate the effect of the new equipment upon the total operating and capital charges of the plant in which the new equipment is to be installed. If these will be reduced, the equipment should be installed. Otherwise, it should not be installed except to increase capacity, and then only when the resultant increase in income from sales will more than cover the added expense. Thus design C_1 in Case I, discussed above, can be installed only in the event that it renders a salable service which will assure an income in excess of \$340 per year.

Selection of Surface Condenser

In order to illustrate how problems (a), (b), and (c) are solved, certain phases of the problem of selecting a surface condenser to serve a turbine will be presented. This problem is too big to discuss completely in this article. Therefore, the assumption will be made that the vacuum desired has been specified and the most economical circulating water velocity has been found. This leaves size as the only remaining independent design factor to be established.

Since the vacuum produced and therefore the service performed by each condenser is the same, that size will be most economical which makes the sum of capital and operating charges against the condenser itself a minimum. The curve of charges against size is given in Fig. 10 and the calculations in Table II. The most economical size for the conditions assumed is seen to be approximately 1100 sq. ft.

In general, when manufacturers submit bids in response to requests from purchasers, the equipment offered as well as the prices will differ among the several bids. When the service to be rendered is a fixed service, as it was assumed to be in this case, that equipment is

TABLE II. PROBLEMS IN SELECTING SURFACE CONDENSER PREPARED TO ILLUSTRATE PROCEDURE IN SELECTING EQUIPMENT FOR ECONOMY

Assumed Data:				
Steam condensed, lb. per hr.				10,000
Heat transmitted to circulating water, B.t.u. per hr.				9,400,000
Coefficient of heat transfer, B.t.u. per hr. per sq.ft. per deg. F.				600
Temperature of entering circulating water, deg. F.				70
Temperature of steam in shell, deg. F.				90
Cost of auxiliary power, cents per kw-hr.				1.00
Efficiency of circulating pump and motor, %				60
External head on condenser circulating pump, ft.				5
Loss of head in water boxes, ft.				3
Number of passes in condenser				2
Cost of surface added to condenser, dollars per sq.ft.				3
Base cost of condenser, dollars				3000
Capital and maintenance charges per year, assumed 16% of initial cost = surface x 3 x 0.16 + 0.16 x 3000				
Hours of service per year				6000
Tube specifications, diameter 3/4 in.; gage 18.				
Loss of head in tubes, 0.3 x length in ft. x number of passes				
1. Circ. water temp. rise, deg. F.	6	10	12	15
2. Outlet temp. of circ. water, deg. F.	76	80	82	85
3. Mean temp. diff., deg. F.	16.8	14.4	13.1	10.8
4. Surface in sq.ft.	932	1,088	1,195	1,450
5. Water flow per tube per pass, lb. per hr.	3,130	3,130	3,130	3,130
6. Total water circulated, lb. per hr.	1,567,000	940,000	783,000	627,000
7. Number of tubes per pass	500	300	250	200
8. Number of tubes in condenser	1,000	600	500	400
9. Surface per tube, sq.ft.	.932	1.81	2.39	3.63
10. Surface per foot of tube	.196	.196	.196	.196
11. Length of tube, ft.	4.76	9.25	12.2	18.5
12. Friction in tubes, ft.	2.85	5.55	7.3	11.1
13. Total friction, item 12 plus 8 ft., ft.	10.85	13.55	15.3	19.1
14. Power consumed by circ. pump, kw.	10.65	7.96	7.5	7.5
15. Annual cost of pump power, 6000 x 0.01 x item 14 - dollars per year	640	477	450	450
16. Annual capital and maint. charges, 0.16 x item 4 x 3 + 480, dollars	928	1,002	1,053	1,178
17. Total annual charges, dollars per yr.	1,568	1,479	1,503	1,628
18. Cost of condenser, dollars	5,796	6,264	6,585	7,350

the best from the point of view of economy which provides the service at the lowest annual cost (capital charges plus operating charges). Let it be assumed in this case that the best condenser is one that costs \$6000 and bears pump power charges of \$500 per year. Let

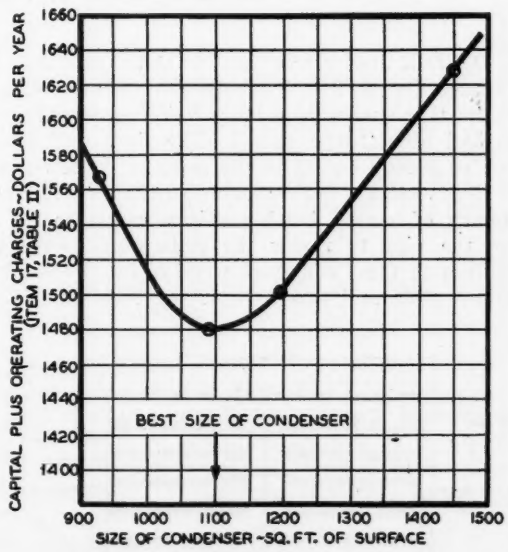


FIG. 10. PLOT OF CHARGES CALCULATED IN TABLE II SHOWING BEST SIZE OF CONDENSER FOR CONDITIONS THEREIN OUTLINED

the cost of installing the condenser, including the cost of making changes to buildings and providing foundations, circulating water conduits, etc., be $6000, and let the gross reduction in operating expenses obtainable by installing the condenser be $6000 per year, before deducting charges on account of power consumed by the condenser circulating water pump. The problem of determining whether or not the installation of the condenser is justified is then solved as follows:

Annual charges against installation costs (assumed equal to 15 per cent of these costs)	$ 900
Annual capital and maintenance charges against condenser (assumed equal to 16 per cent of cost of condenser)	960
Annual charges against condenser on account of power consumed by pump	500
Total charges per year against condenser	$2360
Gross savings per year effected by condenser	$6000
Net annual savings obtainable by installing condenser	**$3640**

The installation of the condenser is obviously justified.

Although selecting equipment for economy is among the more important of the duties of an engineer, he should not, when making a selection, be meticulous in his search for small and uncertain differences in economic performances nor in refining his economic analysis. Service conditions over the life of equipment, the average cost of fuel, labor, etc., the actual rate of obsolescence and depreciation, and prices that will be paid for equipment are seldom if ever exactly predictable at the time economic studies affecting the selection of equipment are made.

Economic Predictions Are Seldom Exact

On that account, the basic data employed in evaluating the economic merits of equipment have in them usually a probable error of considerable magnitude, and there is no point in going to refinements in calculations and investigations that these errors do not warrant. Nor is it necessary to do so. Curves of combined operating and capital charges plotted against investment are usually flat in the vicinity of the point of best investment, so a small error in one direction or the other will not as a rule prove serious.

Designing and purchasing engineers are frequently able, where their experience is adequate, to make a favorable selection of equipment and design factors without first making an elaborate investigation. Where that can be done, in whole or in part, it should be done, for both time and money will be saved thereby. No investigation of a pertinent factor, however, should be omitted unless there is sound assurance that close to the best value of the factor can be established without making an investigation of it.

Revamped Heating System *Presents Difficulties*

Drainage and Rust Troubles Had to be Ironed Out After Replacing Coils with Radiators. By Fred S. Rutledge

IN ORDER to give a conception of the problems that confronted us, Fig. 1 was drawn to show the layout of a heating system in a large building after the system had been "done over." The sixth and seventh floors originally had coils, the same as the lower ones, but they were beyond repairing so the owners bought a bunch of second hand cast-iron radiators for less than the pipe to renew the coils would have cost. Eighteen of these radiators were 26 in., 2 column, 19 sections each, and two were 42 in., 3 column, 17 sections each. As shown, the supply line to the whole layout of radiators and coils was a 2-in. pipe. In all, 20 radiators and 8 coils were fed by this one pipe through a reducing valve. The pressure on the high side was carried at 100 lb. to 140 lb. gage, according to what work was being done and from 15 to 30 lb. gage on the low side, according to the weather. Before the change from coils to radiators, this worked all right but afterward, well, that was something else.

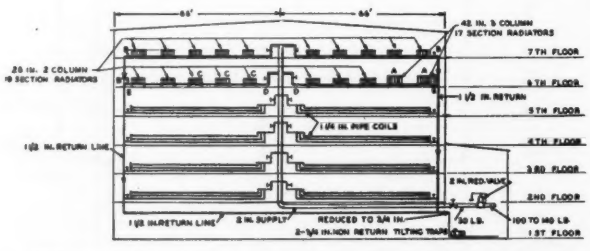


FIG. 1. DIAGRAM OF REVAMPED HEATING SYSTEM

Condensate from these was returned to a trap as shown in Fig. 1 and from there delivered to an open feedwater heater. No trouble had ever been experienced with the heating coils or trap prior to the change.

As shown in Fig. 1, ten 26 in., 2 column, 19 section radiators were placed on the top floor, five in series on each side of the supply line, and eight of the same size on the sixth floor with two 3 column, 17 section 42 in. radiators at AA. They were all connected in series with a 1¼-in. supply piped right straight through from radiator to the return line which was

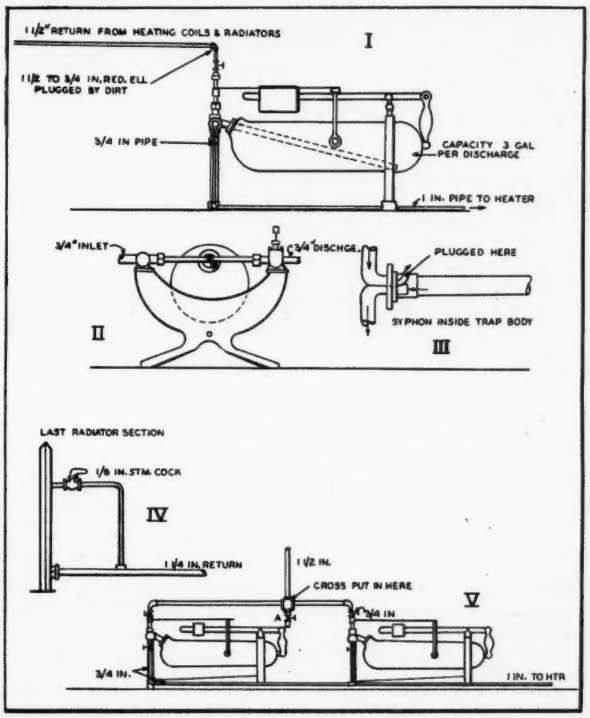


FIG. 2. TRAP AND PIPING DETAILS

1½ in. All ten radiators on the seventh floor worked fine, heating up as they should, after the air was blown out. One ⅛-in. pet cock was put on each string or battery at B.

Those on the sixth floor started off all right but after about 3 hr. the foreman on the sixth floor came down and said that all the radiators on that floor were cold. Investigation showed only radiators marked C hot and all the rest cold. All the rest of the coils and radiators were all right on all the other floors. At the time, 25 lb. pressure was on the system. The Chief said there was not grade enough to carry away the condensate so blocking up was resorted to until there was a pitch of 13 in. from D to E.

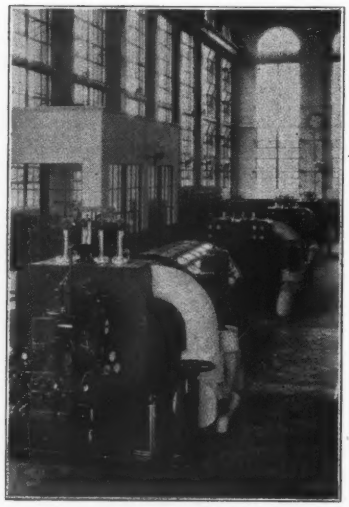
After that the side having all 26-in. radiators worked all right if the pressure was kept at or above 9 lb. at the return end of the radiators, but the other side having the two 42-in. radiators was another story. Pet cocks, automatic air valves and even a connection as shown in Fig. 2-IV were of no avail. They would start to cool off at the top of the sections and gradually work down until the whole radiator was cold and then something else took place. The old layout of coils was connected to the 1½-in. return line and a trap of the non-return, tilting variety was connected to the lowest point from where the condensate was returned to an open heater in which the pressure at no time was over 1 lb. Figure 2-I shows side, and Fig. 2-II end of the trap.

After radiators AA got real cold, the trap would dump and stay that way indefinitely even with 30 lb. pressure on the radiators, which meant 36 to 38 in. on the low side of the reducing valve, there a drop of 6 to 8 lb. being between the reducing valve and the radiators on the seventh floor. Insufficient trap capacity was pronounced the trouble, so another trap was added as shown in Fig. 2-V. This did not help.

Finally, two more 26-in. radiators were secured and put in place of AA. Then they all got hot and stayed hot but further trouble developed. Rust and dirt came down the return line and lodged in the reducing ell as shown in Fig. 2-I. This was cleared out and blown out, but after being connected up again soon plugged up in the outlet of the syphon, inside the trap body as shown in Fig. 2-III. That meant dismantling the whole trap. We put a cross with short pipe and gate valve as shown at Fig. 2-V. The valve was dropped 6 in. below the cross. This was blown out frequently for a few days and since that the valve is opened every 3 hr.

FIRMS WHICH have engaged space for the Power Show to be held in New York City next December are reported as follows, as of June 1: American Car & Foundry Co., Appleton Electric Co., Bailey Meter Co., Bernitz Furnace Appliance Co., Boston Gear Works, Inc., Bristol Co., Buffalo Forge Co., The Philip Carey Co., Chapman Valve Manufacturing Co., Clements Manufacturing Co., Clipper Belt Lacer Co., Crandall Packing Co., Crane Co., Cutler-Hammer, Inc., Diamond Power Specialty Corp., Ehret Magnesia Manufacturing Co., Everlasting Valve Co., Falk Corp., Foster Engineering Co., Garlock Packing Co., James T. Gordon Co., American Brass Co., Armstrong Machine Works, Barco Manufacturing Co., The Borden Co., Botfield Refractories Co., Brown Instrument Co., The Carborundum Co., A. W. Cash Co., Chase Brass & Copper Co., Cling Surface Co., Consolidated Ashcroft Hancock Co., Inc., Cochrane Corp., Dampney Co. of America, Eagle-Picher Lead Co., Ellison Draft Gage Co., Fafnir Bearing Co., Foley Manufacturing Co., Foxboro Co., Gerotor May Co., Hays Corp., Harbison-Walker Refractories Co., E. F. Houghton & Co., The Paul B. Huyette Co., Inc., International Salt Co., The Johnson Corp., Kaye & MacDonald, Inc., The Kron Co., The Leavitt Machine Co., Leeds & Northrup Co., The Lunkenheimer Co., Minneapolis-Honeywell Regulator Co., National Tube Co., Tinius Olson Testing Machine Co., Philadelphia Gear Works, Power, Power Plant Engineering, Reeves Pulley Co. of New York, Inc., John R. Robinson, Sarco Company, Socony-Vacuum Corporation, Sterling Engine Company, Southern Power Journal, C. J. Tagliabue Manufacturing Co., Toledo Pipe Threading Machine Co., Henry Vogt Machine Co., Walworth Co., Wright-Austin Co., Yarnall-Waring Co., Youngstown Sheet & Tube Co., Zobell Electric Motor Corp., Hartzell Industries, Inc., Heating, Piping & Air Conditioning, Industrial Power, International Nickel Co., Jenkins Bros., Johns-Manville Corp., The Korfund Co., Inc., Lead Lined Iron Pipe Co., Lebanon Steel Foundry, Link-Belt Co., Marlin-Rockwell Corp., Morse Chain Co., National Aluminate Corp., Norma-Hoffman Bearings Corp., Parker Appliance Co., Permutit Co., Plibrico Jointless Firebrick Co., Prat-Daniel Corp., Republic Flow Meters Co., J. E. Rhoads & Sons, S. K. F. Industries, Inc., Schutte & Koerting Co., George Scherr Co., L. S. Starrett & Co., Spencer Turbine Co., Taylor Instrument Cos., Technical Publishing Co., Tide Water Oil Co., Veeder-Root, Inc., Wallace & Tiernan Products. Inc., Ward Leonard Electric Co., Weston Electrical Instrument Co., John Zink Co.

Factors Influencing the PARALLEL OPERATION *of* Alternators



By V. E. JOHNSON

DESPITE THE fact that volumes have been written regarding the parallel operation of alternating current generators the subject remains very much of a mystery to many operators, particularly when it comes to the question of field manipulators. Much of this obscurity could be clarified if the phenomenon is analyzed on the basis of a mechanical analogy. With a load consisting entirely of motors, this electrical equipment involved consists essentially of an elastic and somewhat complex coupling between the prime mover and motor shafts.

Regardless of whether the coupling is electrical or mechanical, the total torque on the generator shaft (disregarding losses) is equivalent to the sum of that on the various motor shafts.

In the flexible mechanical linkage shown in Fig. 1 load can be shifted from one unit to the other by manipulating the throttle on the engine. The variation in valve opening can be made manually, or can result from automatic governing in response to indirect impulses set up by a change in the speed ratio of the engine and line shaft.

Applying the same principle to the electrical linkages in Fig. 2, in which the generators I and II are in synchronism and therefore fixed speed relation, the only load shifting possible is that brought about by a change in the relative steam consumptions. The field strength has no effect on the speed of the synchronous machines and therefore none on the governors, nor on the division of the kilowatt output. The adjustment of the main field strength is however accompanied by other electrical and mechanical changes that are of considerable importance.

In a polyphase machine the stator currents set up a magnetic field revolving at synchronous speed, which differs from the rotor only in that the flux "slides" through the iron instead of rotating with it. The electric and magnetic relations involved are therefore approximately those that would exist were the stator made up of inwardly facing salient poles, excited by direct current and arranged to rotate—a mechanical system somewhat like that of certain commercial synchronous motors.

This conception of the stator and rotor fields is

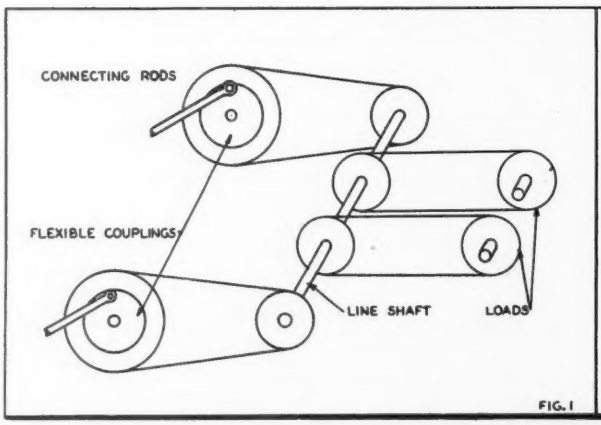


FIG. 1. MECHANICAL ANALOGY OF ENGIENE DRIVING LOADS

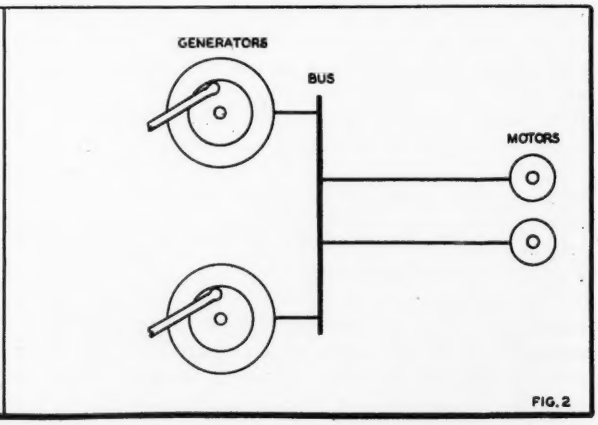
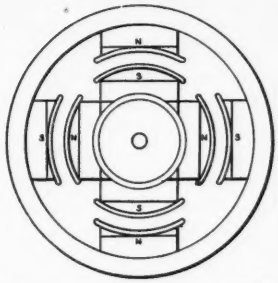


FIG. 2. GENERATORS IN PARALLEL DRIVING LOADS

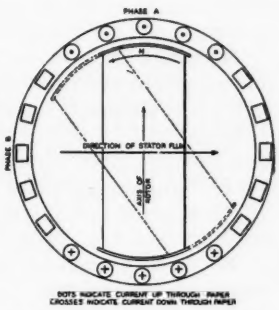


At no load the rotor and stator poles are co-axial. When load is applied the driver member drops back an angle determined by the magnitude of the torque and by the stiffness of the electromagnetic tie.

FIG. 3. PHYSICAL CONCEPTION OF THE REVOLVING FIELD IN A POLYPHASE STATOR

shown in Fig. 3. Regardless of which is the driving member, it pulls the driven member around with it synchronously by magnetic attraction. In a motor the stator field is revolved electrically, in a generator the rotor is driven mechanically.

In either case, the magnetic tie between the two elements is in a sense elastic, as if it consisted of rubber filaments across the air gap. When load is applied the "driven" sags back through an angle determined by the rigidity of the tie and the amount of the pull or torque.



From the "right hand rule" the induced voltages are seen in the directions indicated. At unity power factor the current will be in phase A also so that the stator flux produced by it will be to the right. The reaction of this armature magnetism crowds the flux lines into the trailing side of the pole space. Therefore to maintain the original phase position of the voltage, the pole must move ahead as shown by the dotted lines.

FIG. 4. DIAGRAM OF A TWO PHASE GENERATOR

The load or retarding effect is determined by the external conditions under which the machine operates. The stiffness of the tie is on the other hand essentially a matter of magnetic pull, which in turn is a function of various design and operating constants.

Armature Reaction

With the above general picture in mind, it is possible to get a clearer conception of the changes that take place in an alternator when load is applied.

Figure 4 shows in elementary form a two pole, two phase machine, operating alone, and supplying loads of various characteristics. The sketch adheres to the common convention of representing by means of dots and crosses either the direction of potential or of current flow.

A two pole machine is chosen because in it the electrical and mechanical angles are equal. The two phase winding is chosen because in it certain quadrature relations are more readily visualized. The direction of rotation corresponds to that of the vectors—counter clockwise.

At the instant represented, phase A is having generated in it maximum voltage, for the pressure is a function of the rate of flux cutting and the "round" conductors are evidently being swept directly by the lines of force issuing from the pole tips. In phase B the voltage is zero, for the "square" conductors are not being cut by any magnetism.

It would be possible to represent the phase relations between flux and voltage by a vector diagram as in Fig. 5 (A), indicating that the pressure and "rate of cutting" are in unison or step with each other. It is, however, customary to let the flux vector represent, not the "rate of cutting" but the "linkage," i. e. the number of lines of force threading through or enclosed by the coils of the winding. On this basis phases A and B have respectively zero and maximum linkage, the maximum rate of cutting coming at the instant of zero linkage, and vice versa.[1]

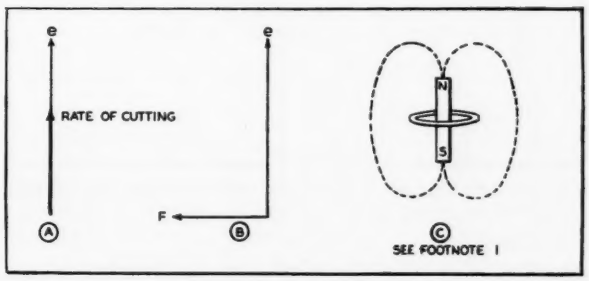


FIG 5. PHASE RELATIONS BETWEEN FLUX AND VOLTAGE AND DIAGRAM EXPLAINING FLUX LINKAGE

This convention results in a vector diagram such as shown in Fig. 5B, in which the flux linkage is 90 deg. ahead of the voltage. Referred to Fig. 4, this simply means that the voltage in phase A is at a maximum when the coils in phase B enclose the greatest amount of magnetism. The crosses and dots in Fig. 4 indicate the direction of potential for the particular conditions represented. If the load be non-inductive, these same symbols will show also the direction of current flow.

In an actual generator the conditions are more complicated as will be shown. The stator, it must be realized, is a magnetic circuit, and consequently the flow of current in the armature (stator) coils sets up a flux of its own, quite independent, in a manner of speaking, of that in the rotor. In Fig. 4 the conditions are such that this armature magnetism is at right angles to the main field, and ¼ of a revolution behind it. This is indicated by the arrow.

Actually, of course, these two fluxes have no separate and independent existence. What really happens is that the field and the stator ampere turns combine to form a resultant flux or magneto-motive force as it is called. The voltage vector corresponding to this resultant flux represents the voltage that would exist were there no impedance drop in the windings. It is displaced from the no load voltage vector by the "angle of advance."

The existence of this angle, which represents a time interval, indicates that no longer does the voltage become of maximum value when the axis of the main field lies on the center of the phase coils, but is instead delayed until the rotor has turned past that point to the new position indicated by the dotted lines in Fig. 4.

It is, however, an error to assume that all of the armature flux reacts with the main field, and that the

[1]EDITOR'S NOTE—To understand more clearly what is meant here consider Fig. 4C, which shows a single turn of wire in the center of which is mounted a bar magnet. The lines of force due to the magnet it will be seen entirely encircle the single turn of wire. This is what is meant by maximum linkage.

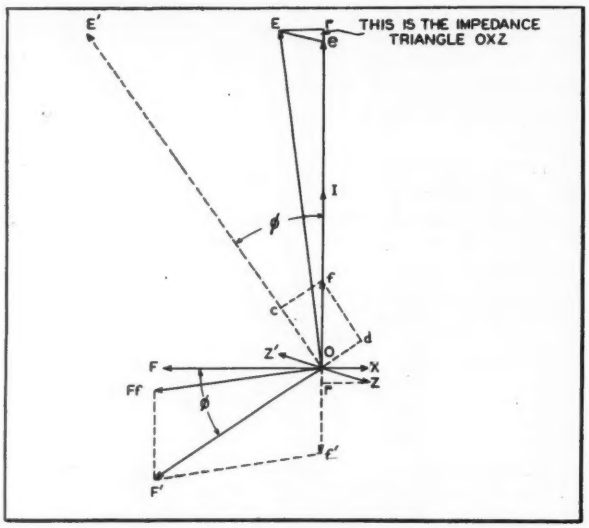


FIG. 6. EFFECT OF ARMATURE REACTANCE AND REACTION ON REGULATION, AT UNITY POWER FACTOR

resultant flux is composed of two quadrature vectors. A not inconsiderable portion of the stator magnetism circulates in paths distinct from the rotor, and so has no effect on the exciting flux that crosses the air gap.

A closer analysis then demands that the stator flux be further subdivided. The first part of the stator magnetism is that which combines with, and reacts on the rotor field. The second (made up of several components) causes the inductive drop in the windings. The vector diagram in Fig. 6 takes this more accurate solution into account. It represents unity power factor conditions. While this diagram appears complicated in reality it is quite simple and should be perfectly understandable to anyone from the following description.

The current I in phase with the terminal pressure e produces respectively the ohmic drop r in phase with the current, and the reactive drop x at right angles to the current. In order, therefore, that e may remain constant, the internal voltage generated must be augmented by the impedance z, and therefore assume the position and value E. This vector E is the sum of e and x added trigonometrically.[2]

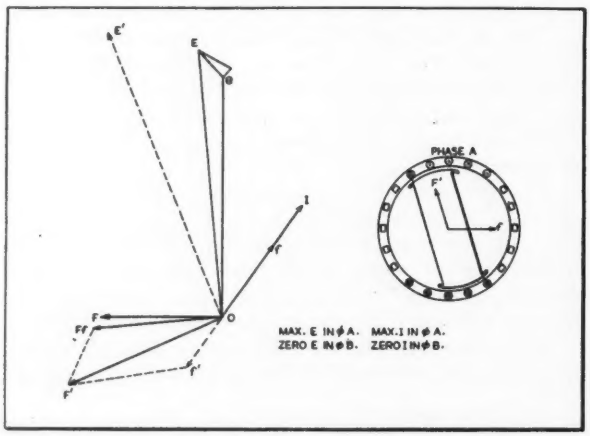


FIG. 7. DIAGRAM SIMILAR TO THAT OF FIG. 6 BUT SHOWING REGULATION AT 80 PER CENT POWER FACTOR

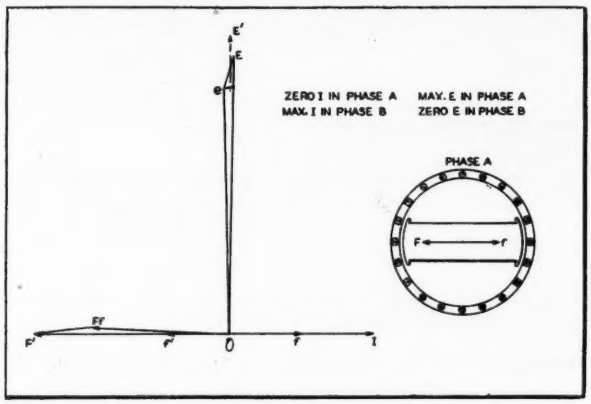


FIG. 8. REGULATION AT 0 PER CENT POWER FACTOR (LAG). NOTE: SOME LINES HAVE BEEN OMITTED TO AVOID BLURRING

From our discussion in connection with Fig. 5B it is obvious that to generate the pressure E a flux Ff in leading quadrature with it must link the stator coils. Were it not for the reaction of the armature flux, this vector Ff would represent also the main field. As it is, however, a component must be added to the rotor field to compensate for the effect of the stator reaction.

Inasmuch as the stator flux occupies the position and has the magnitude f, the magnetism to overcome it must be f′ (drawn directly opposite to f in the diagram). The resultant of Ff and f′ is F′ representing the main field flux, and displaced from F by the angle ϕ = e o E′ = F o F′. This is made up of the angle F o Ff due to armature reactance, and the angle Ff o F′ due to armature reaction. The field strength has been increased from F to F′ by two increments, to offset respectively the reactance and reaction.

Figures 7 and 8 show Fig. 6 modified to represent operation at 80 per cent and zero power factor. Under these conditions the angle of lag affects the generator adversely by reducing the displacement between the internal voltage and the impedance drop. It also further affects it by bringing the stator magnetism more and more into direct opposition to the main field. For the same current, the excitation must be increased as the angle of lag becomes larger.

[2]NOTE: The impedance triangle, XOZ it will be seen is repeated at the top of the vector e.

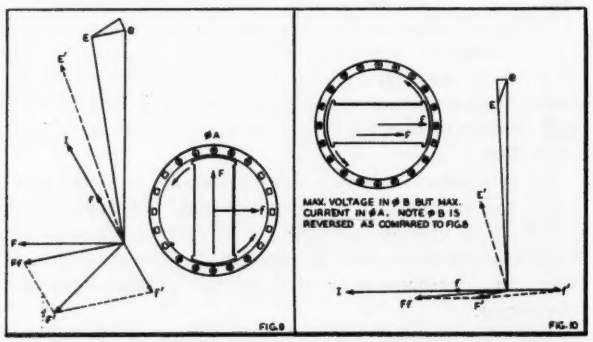


FIG. 9. REGULATION AT 80 PER CENT LEADING POWER FACTOR

FIG. 10. REGULATION AT 0 PER CENT LEADING POWER FACTOR. NOTE: SOME LINES ARE OMITTED TO AVOID BLURRING

Two similar diagrams, Figs. 9 and 10, show that with leading currents the voltage drop under load is much less, and that, as a matter of fact, the regulation may become negative—the voltage rising with the load.

From these diagrams it appears that the relative position of the rotor is not fixed with regards to the terminal voltage, but varies with the load and excitation. This action naturally has a direct bearing upon the parallel operation of alternating current generators. This aspect of the subject will be discussed in detail in another article in a subsequent issue.

Coal Car Thawing Equipment

FREEZING WEATHER often presents great difficulty in dumping coal from cars into hoppers at power plants on account of the fact that the coal freezes to the shell plates of the cars.

Engineers sometimes resort to the use of steam jets directed against the sides and bottoms of the cars, or to the building of fires between the tracks on both sides of the cars to thaw the ice which prevents complete dumping of the coal. Both of these methods are inefficient and costly and have the decided disadvantage of failure to overcome the difficulty in a satisfatory manner.

To eliminate the difficulties described, and to provide an efficient and economical method of preparing the frozen cars for dumper operation at much greater capacity than is practical by other methods, car thawing equipment has been developed by the Wellman Engineering Co. of Cleveland, O. The equipment consists of duplicate units, disposed on opposite sides of the approach tracks leading to the car dumper mounted on tracks laid at right angles to the car tracks. The units are capable of movement toward the car side in order to secure heat concentration on the car, and away from the heated car to provide clearance for the passage of the car along the track.

Sliding gates, operated in conjunction with the heating units are provided at each end. The movement of the heating units also actuates the gates. As the units move toward the sides of the car the end gates close and the car is thus completely surrounded.

Each unit comprises a structural frame movably mounted and carrying as a heating element a box, approximately 10 ft. high and 50 ft. long, which is provided with perforated front plates through which the heated air is directed against the side of the car. Heat is supplied by an oil burning furnace from which the products of combustion, mixed with air, are conducted to a blower and through suitable ducts to the heat box.

Sufficient air is mixed with the products of combustion to reduce the temperature to about 350 to 400 deg. F., a temperature much higher than steam, but not sufficient to damage the car.

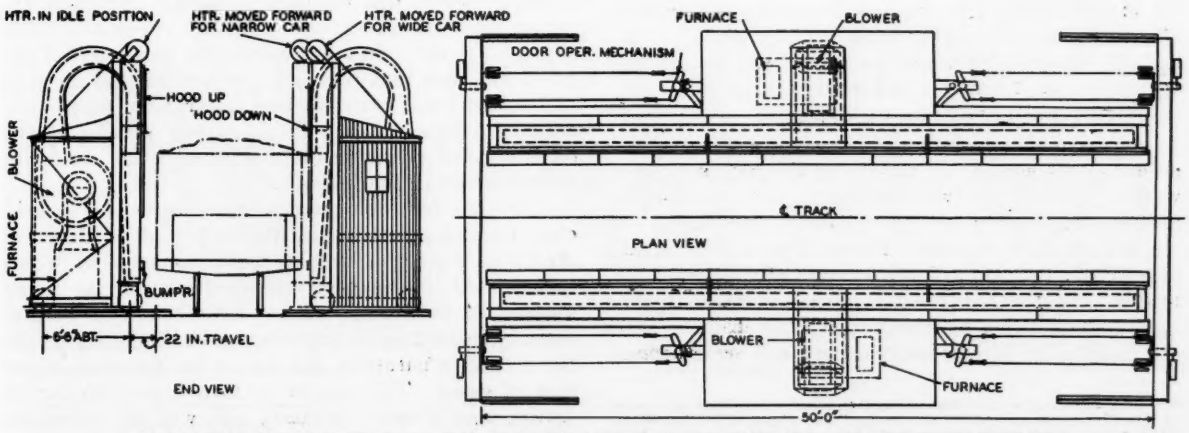
It is estimated that this equipment is capable of thawing a car sufficiently to loosen the coal frozen to the inside of the shell so that the contents can be dumped, in about two minutes. This operation will require about 35 gal. of oil at 30 deg. Baumé per hour. Each minute about 26,000 cu. ft. of air at 400 deg. F. will be delivered by the two units, against the car.

The electrical equipment may be adapted to alternating or direct current and will include one motor for each of the following drives: Blower, 20 hp.; moving motor, 10 hp.; hood, 3 hp.; air compressor, 3 hp.; and oil pump, ½ hp.

The heat ducts and heat boxes are insulated by a standard rock wool insulating material—approximately 4 in. thick, which is protected by a galvanized covering properly secured in place. The heat box is divided into six sections for each unit and each section is separately insulated, and capable of removal in case repairs are necessary.

Temperature of the outlet heat is accurately controlled by adjustment of dampers in the oil furnace. The perforated face plates of the heat box are provided with deflecting vanes which direct the heat downward. These vanes are adjustable so that the heat will be uniformly distributed over the entire area.

In addition to these adjustments provision is also made enabling the complete closure of either or both of the end sections in case short cars are being thawed, thus giving effective heating surface 33, 42 or 50 ft., as desired.



THAWING EQUIPMENT FOR OPEN TOP RAILROAD CARS USES OIL FUEL TO SUPPLY HEAT

Julian E. Tobey
Chief Engineer of Power Plants,
The Studebaker Corp.,
South Bend, Ind.,

Says

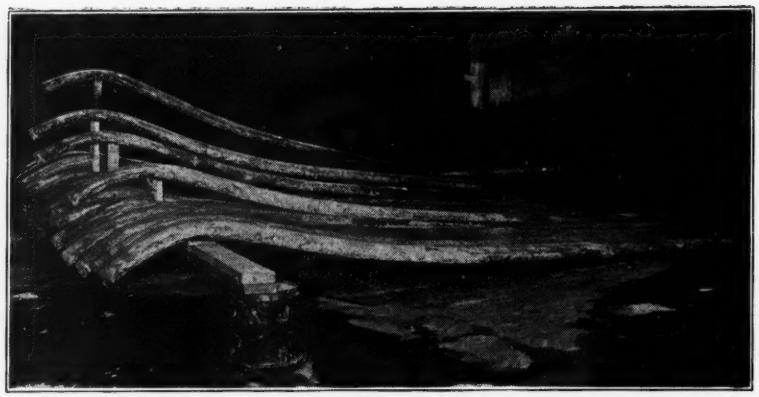


FIG. 1. WITH THE ORIGINAL BAFFLE ARRANGEMENT MANY TUBES WERE WARPED BY EXCESSIVE TEMPERATURES

BAFFLE CHANGES *Reduce Boiler Maintenance*

New Baffles Cut Draft Loss in Half and Eliminate Tube Failures Without Affecting Superheat or Exit Gas Temperatures

CERTAIN CHANGES were made to the gas baffling in several large boiler units to reduce draft loss and to correct an irregularity in circulation on the water side. Referring to reduction in draft loss, the problem was to accomplish this without causing an increase in exit gas temperature. The circulation difficulty* consisted of dry tubes at high ratings which resulted in the warping and burning of the tubes.

Tubes affected were in the rear of the first bank; namely, rows number four, five, six, and seven, the upper half of the tubes being the portion of each tube affected. Figure 1 shows some of the warped tubes which were removed. The manner of warping was always toward the front of the furnace and the tubes would be found with the seventh row buckled against the sixth, the sixth against the fifth, the fifth against the fourth, and the fourth row buckled slightly toward the third row. Figure 2 shows the original method of baffling and the location of the superheater. Water circulation difficulty existed to a certain degree with the original baffling as was evidenced by the analysis of water samples taken from various zones of the boiler.* A study of the boiler water, particularly the concentration of solubles and insolubles, revealed stagnant zones and circulation irregularities.

Replacement of the original superheaters became necessary on account of failure of the headers due to warping caused by two conditions: structural weakness of the headers and the excessive temperature to which they were exposed. Figure 3 shows the method of baffling employed and the location of the new superheater with the superheater headers protected from high temperatures by the upper cross baffle. After the installation of new superheaters and cross baffling, the circulation difficulty was much aggravated and resulted in serious tube damage.

All Solids Deposited

Considerable study was given the matter and it was felt that, with both baffle arrangements, the upper sections of tubes in the rear of the first bank were evaporating water at so much faster than the lower sections of the same tubes that the circulation as developed in the lower section was not sufficient to supply enough water to the upper section. The result was that the upper sections became dry and steam bound. This had a secondary effect in that it permitted the deposition of salts from the water to the tubes in what was practically an evaporation to dryness process which rendered all salts insoluble.

This deposition of material on the heating surfaces produced an insulating effect which permitted an excessive rise in the temperature of the metal and resulted in the destruction of the tubes. The first bank of tubes, seven, was too deep to permit the gases entering from the furnace to properly sweep the tubes from end to end. In other words, the movement of the gases was such that they did not penetrate to the rear of the first bank, lower section, to promote proper circulation. This resulted in the upper section of the tubes affected receiving too much heat while the lower section received too little.

Then the fact that the new superheater was located close to, and parallel with, the first bank of tubes, as shown in Fig. 3, caused a certain confinement which accentuated the temperature conditions on the upper sections of these same tubes. This condition became more intensified as the superheater became dirty on the fire side as it naturally did due to the direction of the flow of gases. This was an awkward position for effective soot blower operation and was not accessible for manual cleaning when the boiler was down for

*The question of circulation and concentration was discussed by Mr. Tobey in an article Mechanical Problems of Boiler Water Treatment which appeared on page 491 of the May 1, 1930, issue of Power Plant Engineering.

routine maintenance. When the resistance through the superheater increased due to accumulation of fly ash and soot, more and more gases were by-passed over the top. This not only lowered the efficiency of the superheater but caused trouble in the water circulators between the front and middle drums.

Metal Temperatures

To determine what was actually happening within the boiler tubes in question, thermocouples were welded to several No. 7 row tubes, that is, tubes in the last row of the first bank, at two levels: one located three feet down from the upper end of the tube and the other six feet down from the upper end (the full length of these tubes was approximately nineteen feet).

With baffles as shown in Fig. 3, the thermocouple readings showed that with the boiler operating from normal rating on up into high ratings the tubes were dry for a depth of at least 6 ft. (that being as far down the tube as the thermocouples were installed). The metal temperatures ranged from 800 to 1250 deg. F. whereas the saturated steam temperature was about 390 deg. F. In fact, at times the metal temperature was within 150 deg. F. of the temperature of the gases.

By this time sufficient information had been obtained to clearly indicate corrective measures to eliminate the trouble. Two steps were necessary. Rebaffle front bank of tubes and change location of superheater.

The manner in which these changes were accomplished is shown in Fig. 4. The sub-baffle installed in the mid-section of the front bank causes the gases to split two ways. A large portion of the gases penetrate to the rear tubes at the lower end of the bank and give these tubes the effect of a full sweep from bottom to top. The jog in the first vertical baffle promotes a cross flow effect.

Superheater Support

The first three rows of tubes in the front bank are subjected to and absorb most of the radiant heat from the fire so that there is no undesirable effect from bypassing a portion of the gases to the rear of this bank. These tubes are still swept by the gases which go to the upper throat opening. Changing the location of the superheater consisted of tilting it backwards so that it was close and parallel to the second tube bank instead of the first tube bank. A short baffle was installed at the top of the superheater to prevent short-circuiting, thus all gases were forced to pass through the superheater.

To accomplish these changes, several structural details had to be worked out in connection with the method of supporting the sub-baffle and the upper section of the superheater. Special cast-iron clamps each with a projecting boss were made and installed on tubes to support the baffle from the lower end and, being between two rows of tubes, the baffle was thus held in place. An improvement was made in the method of securing the upper end of the superheater over previous practice. Instead of having the top of the superheater being supported by the tube bank, it was supported independently of the boiler proper by means of the construction shown in Fig. 4. Inasmuch as the superheater headers are and always were supported independently of the boiler proper, the new treatment of the top support eliminated friction and strain between the boiler and superheater.

All Units Changed

Results of the changes to both baffling and superheaters were most gratifying. The dry tube condition was entirely eliminated at all ratings. The same thermocouple installations showed the metal temperature of the tubes maintaining between 390 and 400 deg. F. regardless of boiler rating. Draft loss through the boiler from the original type of baffling to the final baffling arrangement was reduced from 0.85 to 0.45 in. of water at 225 per cent of boiler rating without entailing any increase in exit gas temperatures, which were very satisfactory.

There was no loss in superheat temperature as might have been expected from the shading effect of the sub-baffle. In fact, over a long period, superheat temperature was improved because of greater accessibility for cleaning. Subsequently, changes were made to baffling and superheaters in all boilers in the plant according to the new arrangement and these have since operated for a period of two years with very satisfactory results.

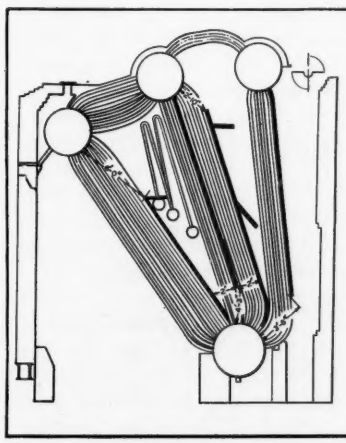


FIG. 2. ARRANGEMENT No. 1 AS ORIGINALLY INSTALLED

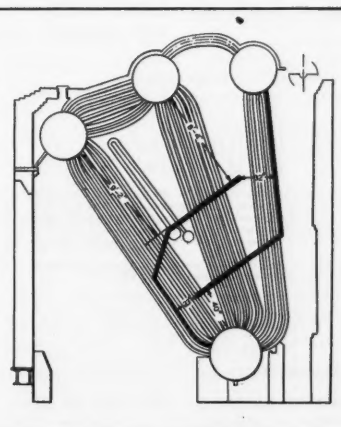


FIG. 3. ARRANGEMENT No. 2 WHICH DID NOT CORRECT CONDITIONS

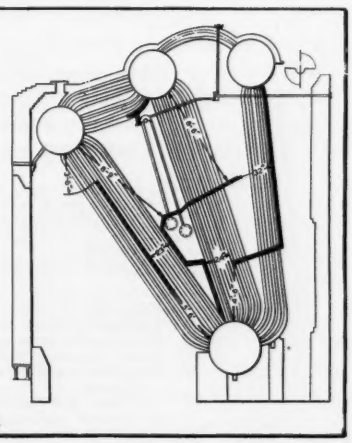


FIG. 4. ARRANGEMENT No. 3 WHICH PROVED SATISFACTORY

Comparative Cost of Fuels for Power Plant Use

H. M. Faust, Research Engineer, Ohio State University, Tells, in the Engineering Experiment Station News, How to Figure the True Cost of Fuel

MUCH TIME and money are spent by large power plants to make sure that the most economical fuel is purchased and efficiently used but unfortunately a large part of the industrial fuel is burned in small plants where knowledge of the procedure for making a study of costs is not always available. This study is offered to assist boiler plant owners and operators in making an accurate choice of fuel for

ECONOMIC STUDY OF PLANT OPERATION USING TWO DIFFERENT FUELS

Item No.		Coal X	Coal Y	Total
	General			
1.	Capacity of boiler room (six 500-hp. units), rated boiler hp.	.....	.....	3,000
2.	Maximum plant steam demand, boiler hp.	.....	.....	4,000
	Coal Analysis, as Received			
3.	Moisture, per cent	3	6	
4.	Ash, per cent	8	12	
5.	Volatile matter, per cent	36	36	
6.	Fixed carbon, per cent	53	46	
7.	Heating value, Btu	13,500	11,800	
8.	Ash refuse, per cent of coal as fired	10.7	16.0	
	Test Operating Conditions			
9.	Feedwater temperature, deg. fahr.	200	150	
10.	Steam pressure, lb. per sq. in. gage	200	200	
11.	Superheat, deg. fahr.	0	100	
12.	Boiler rating 24 hour average, per cent	125	125	
	Test Results			
13.	Actual evaporation per lb. coal as received, lb. = [Av. water fed per hr., lb.]/[Av. coal burned per hr., lb.]	9.83	7.22	
14.	Heat absorbed by boiler per lb. steam, 1000 Btu. = [Total heat per lb. steam—heat in feedwater]/1000	1.031	1.141	
15.	Equivalent evaporation per lb. coal as received, lb. = [Item 12 × Item 14 × 1000]/970.2	10.42	8.45	
16.	Heat absorbed by steam in boiler per lb. coal as received, 1000 B.t.u. = Item 13 × Item 14	10.15	8.23	
17.	Efficiency, boiler furnace and grate, per cent = [Item 16 × 100,000]/Item 7	75	70	
	Cost Data			
18.	Total delivered cost (including mine price, freight rate and handling charge)	$2.79	$2.16	
19.	*Fuel cost per 1000 lb. steam (actual evaporation) = $\frac{\text{Item 18} \times 1000}{2000 \times \text{Item 13}}$	$ .141	$ .149	
20.	Fuel cost per 1000 lb. of equivalent evaporation = $\frac{\text{Item 18} \times 1000}{2000 \times \text{Item 15}}$	$ .134	$ .128	
21.	Fuel cost per million Btu absorbed by steam boiler = $\frac{\text{Item 18} \times 1000}{2000 \times \text{Item 16}}$	$ .137	$ .131	
	Economic Results (yearly basis)			
22.	Maximum attainable output per boiler with present equipment, boiler hp.	800	720	
23.	Annual fuel consumption: Coal X is known, tons	30,000	.....	
	Coal Y = Consumption Coal X × $\frac{\text{Item 16 for Coal X}}{\text{Item 16 for Coal Y}}$, tons	.....	36,800	

* The fuel cost per 1,000 pounds of steam (actual evaporation) is an inaccurate basis on which to compare the relative performance value of fuels. This is true because the actual evaporation does not take into consideration operating conditions such as the temperature of the feedwater, superheat, etc., which are plant operating conditions not in any way dependent upon the coal used, but which never-the-less do affect the capacity, steam production, and actual evaporation per pound of fuel.

Correct fuel cost comparisons may be made on the basis of cost per unit of equivalent evaporation or per unit of heat absorbed by the boiler as given in items 20 and 21.

				COAL Y COMPARED WITH COAL X	
		Coal X	Coal Y	Saving	Increased Expense
I.	Fuel cost (annual)	$83,700	$79,400	$4,300	.....
II.	Overhead or fixed charge cost	.....	.....	.....	$2,480
III.	Plant maintenance cost	.....	.....	450	.....
IV.	Labor operating cost	.....	.....	.....	900
V.	Fuel handling and ash refuse disposal cost:				
	Labor	.....	.....	.....	750
	Wear and tear on equipment	.....	.....	.....	250
	Sale of additional ash refuse	.....	.....	1,350	.....
VI.	Auxiliary power cost	.....	.....	.....	500
	Gross	.....	.....	$6,100	$4,680
	Net	.....	.....	$1,420	.....

their particular needs. The comparison given is that of two coals, but the method of computing unit costs would apply to any fuel.

Let us consider two coals in a typical plant, Coal X, which it is assumed has in the past been the normal fuel employed, and Coal Y, a competing fuel. The table shows this comparison. The figures given do not represent any actual situation but will serve to show how the analysis of an actual case might be made. Six cost items, affected normally by the fuel used, may be mentioned in connection with the operation of a plant. They are: Fuel cost; overhead or fixed charge cost; plant maintenance cost; labor operating cost; fuel handling and ash refuse disposal cost; auxiliary power cost.

The problem is greatly simplified if the fuels considered all carry the plant load satisfactorily with the equipment installed and all require the same maintenance, labor, fuel handling, ash refuse disposal, and auxiliary power costs. In such a case it is necessary to determine only the fuel cost per million B.t.u. absorbed by the steam in the boiler (Item 21, in table) prevailing with each fuel, to show which coal is the most economical for use in the plant under consideration. Such a case is rarely found, but frequently the difference in cost, due to the last five items enumerated for comparison of fuels, is so slight that it may be justifiable to neglect them. Failure to consider all six items may, however, lead to erroneous opinions and the use of a fuel which is not the most economical.

Study May Be Detailed

It will be noted that the items have been figured on a yearly basis. The total costs have not been computed, only the saving or expense involved by the use of the competing Coal Y instead of the normal Coal X has been indicated. By comparing the total computed savings with the total calculated increased expense involved when using Coal Y instead of the Coal X we find the cost advantage or disadvantage of Coal Y. The consideration of a greater or smaller amount of detail than is indicated in this discussion may, depending upon conditions in any individual plant, be necessary to determine which fuel will produce the greater economy.

Plant equipment data and test results, with methods of computing them, are given as Items 1 to 17 in the table and computation of the economic results are explained below. The item numbers refer to those used in the table. Power plant fuel costs are most accurately indicated by the amount of heat which is made available in the form of steam per unit of fuel consumption, rather than by the efficiency obtained with the fuel. In the table the annual tonnage has been computed from the results of comparative evaporation tests. The annual fuel cost with each coal has been computed by multiplying the annual consumption by the delivered cost of the coal.

When comparing fuels, overhead or fixed charge cost may be affected by two major conditions: Inability of fuel to carry the plant load satisfactorily with present equipment; inability of fuel to operate without objectionable smoke.

Expenditure of additional money is generally necessary to correct either condition. It will be noted in Item 22 of the table that the maximum satisfactory available output per boiler is given as 800 boiler hp. for the normal Coal X and 720 hp. for Coal Y. The maximum plant steam demand is 4000 boiler hp. so the installation of a 500 hp. unit would be desirable. If a flat cost of $45 per rated boiler hp. for stoker and boiler installation is assumed, it would require an additional overhead of $45 $\times$ 500, or $22,500. Using 11 per cent for depreciation and interest, the annual increased overhead charge if using Coal Y is computed to be $2480. This amount is shown as an increased expense for Coal Y.

Additional Labor

Annual maintenance cost for stoker parts, brick and the necessary labor, when using Coal Y has in this example been assumed to have been found $450 lower than when using Coal X (due to the lower ratings required when using an extra boiler). This amount has been credited, therefore, as a saving in favor of Coal Y. It has also been assumed in this example that the use of another boiler during the heavy load period will require one additional man. Coal Y has been charged therefore with the expense of one fireman helper on the day shift, which at $3.00 per day and 300 days per yr. amounts to $900.

Any increased cost due to the additional quantity or the more difficult handling of the fuel and ash refuse of one fuel over the other should be computed and taken into consideration on an annual basis. The increased cost or profit of ash refuse disposal of one fuel over the other should be computed and taken into consideration on an annual basis.

Two and one-half man-hours per day at $1.00 per hour, for 300 days per yr., or a total of $750 has accordingly been charged against Coal Y for increased labor. An increased annual expense of $250 for power consumption and wear and tear on the coal crusher and conveyor system when using Coal Y has been charged against it. The ash refuse from this plant is assumed to be sold at the rate of $0.50 per t. Using the annual consumption per year and the percentage of ash refuse as given by Items 23 and 8, gives 36,800 $\times$ 0.16 or 5900 tons of refuse annually with Coal Y, and 30,000 $\times$ 0.107 or 3200 tons with Coal X. The difference of 2700 tons at $0.50 per ton produces an advantage of $1350 per year in favor of Coal Y.

Power for fuel feeding, pulverization, or for draft fan operation, may change slightly with the use of different fuels. In this example $300 has been charged annually against Coal Y for increased auxiliary power, to cover the operation of auxiliaries for the additional boiler.

Summary

The items of saving and increased expense of Coal Y over Coal X indicate the gross savings to be $6100 and the added expense to be $4680, providing a net saving of $1420 annually if Coal Y were used instead of the normal Coal X. Obviously, Coal Y is the more economical fuel under the conditions prevailing in the plant under consideration, and, if the reliability of its source of supply is assured, arrangements could profitably be made to use it.

Coal Classification *by* Grade *and* Rank *Completed*

Standardization Sponsored by A. S. T. M. Provides Assistance to Both Buyer and Seller

DURING THE PAST 100 yr. many systems of classification of coal have been proposed. Several of these have become widely known and have provided broad, general designations for various ranks of coal. But they do not meet the demands of today and have not been widely adopted. Realization of this situation brought about a united effort which in 1926 resulted in the formation of a sectional committee fully representative of producing, distributing and consuming interests, governmental interests and technical societies. With the American Society for Testing Materials as sponsor under the auspices of the American Standards Association, this committee has been engaged for more than seven years in an extensive investigation of North American coals.

Proposed tentative specifications covering the classification of coal by rank and by grade, just published by the A.S.T.M. and summarized here complete an important part of the work of this committee. It was recognized that coals could be usefully classified according to their inherent composition and properties, along three different lines: By rank, or according to the degree of metamorphism or progressive alteration in the natural geological process from lignite to anthracite; by grade, or according to nature and amount of impurities in the coal, sizes of lumps, etc.; by type, or varieties such as common, cannel, boghead, or algal, and splint coals. (The work on this classification has not reached the point where it can be published.)

Only those classifications of coal relating directly to the inherent properties or characteristic behavior of the fuel, such as proximate and ultimate analysis, heat value, mineralogic description, purity, caking properties, strength, ability to resist weathering, combustion behavior, etc., are considered in the report of the sectional committee. Many other points were suggested for consideration by the committee, but were eliminated in the interest of practicability.

In America, from an early date, proximate analysis has been preferred to ultimate analysis for the classification of coal according to rank. For years coals have been plotted either according to their fixed carbon (or volatile matter) contents and B.t.u., or according to their ultimate analysis. Results obtained with either method from graphical studies of hundreds of American and foreign coals were found to be similar, however. The combination of fixed carbon and B.t.u. was chosen by the committee because (1) these figures are nearly always available or may be obtained at small cost; (2) this method more nearly conforms to long-established American usage.

Calculation to the mineral-matter-free basis has been specified for the classification of coal by rank. For accurate work, the ordinary "ash-free" basis is not satisfactory, since the weight of ash left in the standard determination is distinctly less than the weight of mineral impurities present in the raw coal. This is due to loss of water from hydrated minerals, carbon dioxide from carbonates, conversion of pyrites to iron oxide, etc. Studies have been made of float-and-sink methods, and acid treatments to obtain low-ash or ashless coal, and exhaustive studies have been made of several average correction formulas which can be applied to the regular analyses.

It was found desirable to include agglutinating specifications in establishing the boundary between

Legend: F.C. = Fixed Carbon V.M. = Volatile Matter B.t.u. = British thermal units

Class	Group	Limits of Fixed Carbon or B.t.u. Mineral-Matter-Free Basis	Requisite Physical Properties
I. Anthracitic	1. Meta-anthracite	Dry F.C., 98 per cent or more (Dry V.M., 2 per cent or less)	
	2. Anthracite	Dry F.C., 92 per cent or more and less than 98 per cent (Dry V.M., 8 per cent or less and more than 2 per cent)	
	3. Semianthracite	Dry F.C., 86 per cent or more and less than 92 per cent (Dry V.M., 14 per cent or less and more than 8 per cent)	Non-agglutinating[a]
II. Bituminous[c]	1. Low volatile bituminous coal	Dry F.C., 77 per cent or more and less than 86 per cent (Dry V.M., 23 per cent or less and more than 14 per cent)	
	2. Medium volatile bituminous coal	Dry F.C., 69 per cent or more and less than 77 per cent (Dry V.M., 31 per cent or less and more than 23 per cent)	
	3. High volatile *A* bituminous coal	Dry F.C., less than 69 per cent (Dry V.M., more than 31 per cent); and moist B.t.u., 14,000[d] or more	
	4. High volatile *B* bituminous coal	Moist[b] B.t.u., 13,000 or more and less than 14,000[d]	
	5. High volatile *C* bituminous coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Either agglutinating or non-weathering[a]
III. Subbituminous	1. Subbituminous *A* coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Both weathering and non-agglutinating
	2. Subbituminous *B* coal	Moist B.t.u., 9500 or more and less than 11,000[d]	
	3. Subbituminous *C* coal	Moist B.t.u., 8300 or more and less than 9500[d]	
IV. Lignitic	1. Lignite	Moist B.t.u., less than 8300	Consolidated
	2. Brown coal	Moist[b] B.t.u., less than 8300	Unconsolidated

TABLE I. CLASSIFICATION OF COAL ACCORDING TO RANK AS OUTLINED IN NEW STANDARDS

[a] If agglutinating, classify in low-volatile group of the bituminous class.
[b] Moist B.t.u. refers to coal containing its natural bed moisture but not including visible water on the surface of the coal.
[c] Pending the report of the Subcommittee on Origin and Composition and Methods of Analysis, it is recognized that there may be non-caking varieties in each group of the bituminous class.
[d] Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of B.t.u.
[e] There are three varieties of coal in the High-volatile *C* bituminous coal group, namely, Variety 1, agglutinating and non-weathering; Variety 2, agglutinating and weathering; Variety 3, non-agglutinating and non-weathering.

Abstract of Proposed Tentative Specifications for Classification of Coals by Rank and Grade

These specifications cover the classification of coals by rank, that is, according to its degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite. The basic scheme of classification is according to fixed carbon and calorific value (expressed in B.t.u.) calculated to the mineral-matter-free basis. The higher-rank coals are classified according to fixed carbon on the dry basis; and the lower-rank coals according to B.t.u. on the moist basis. Agglutinating and slacking indices are used to differentiate between certain adjacent groups.

(a) Fixed Carbon and B.t.u.—Coals shall be classified by rank in accordance with Table I. Coals having calorific values of 14,000 B.t.u. or more on the moist, mineral-matter-free basis, and coals having fixed carbon of 69 per cent or more on the dry, mineral-matter-free basis, shall be classified according to fixed carbon on the dry, mineral-matter-free basis; coals having calorific values less than 14,000 B.t.u. on the moist, mineral-matter-free basis shall be classified according to B.t.u. on the moist, mineral-matter-free basis, provided the fixed carbon on the dry, mineral-matter-free basis is less than 69 per cent.

(b) Weathering Index.—Coals showing average weathering indices of less than 5 per cent shall be considered non-weathering, a coal showing average weathering indices of 5 per cent or more shall be considered weathering from the standpoint of classification.

(c) Agglutinating Index.—Coals having average agglutinating indices of 500 g. or more at a ratio of 15 part sand to 1 part coal shall be considered agglutinating from the standpoint of classification.

Symbols for Expressing Classification

(a) The position of a coal in the scale of rank may be expressed in condensed form as in the following example:

(62—146)

in which the parenthesis signifies that the contained numbers are on the mineral-matter-free basis. The first number represents fixed carbon on the dry basis, reported to the nearest whole per cent. The second number represents B.t.u. on the moist basis, expressed as hundreds of B.t.u. (to the nearest hundred); for example, 14,580 B.t.u. would be represented as 146.

(b) When agglutinating or weathering properties enter into the classification of a coal, they shall be expressed outside and immediately following the parenthesis by the following symbols:

ag. = agglutinating
na. = non-agglutinating
we. = weathering
nw. = non-weathering

(c) Symbols describing the grade of coal shall be placed after the parenthesis, as shown in the following illustration:

(62-146) 132-A8-F24-Sl.6

The numbers in parenthesis are on the mineral-matter-free basis, and give the position of the coal in the scale of rank as explained in Paragraph (a) of this section. The numbers and symbols following the parenthesis show the position of the coal according to classification by grade, that is, 132-A8-F24-Sl.6 indicates a heating value of approximately 13,200 B.t.u., an ash content of 6.1 to 8.0 per cent, inclusive, an ash-softening temperature of 2400 to 2590 F, inclusive, and a sulphur content of 1.4 to 1.6 per cent, inclusive.

ABSTRACT OF PROPOSED TENTATIVE SPECIFICATIONS FOR CLASSIFICATION OF COALS BY GRADE

These specifications cover the classification of coals according to quality, as determined by calorific value, ash and sulphur content, and ash-softening temperature. Other properties, such as resistance to breakage, screen size and caking properties are under consideration.

Example

The calorific value of a coal shall be expressed in hundreds of B.t.u. to the nearest hundred, for example, 13,150 to 13,249 B.t.u, inclusive, shall be expressed as 132. The ash, softening temperature of ash, and sulphur content shall be expressed by symbols in accordance with the table herewith. For example, a coal designated as 132-A8-F24-Sl.6, indicates a heating value of approximately 13,200 B.t.u., an ash content of 6.1 to 8.0 per cent, inclusive, an ash-softening temperature of 2400 to 2590 F., inclusive, and a sulphur content of 1.4 to 1.6 per cent, inclusive.

Symbols for Expressing Classification, rank precedes grade

In reporting grade designations, the calorific value shall be given first, followed by the symbols separated by dashes, in the order shown in the example given.

When both rank and grade of a coal are reported, the grade designation shall follow the rank designation as shown by example in the Specifications for Classification of Coal by Rank.

anthracite and bituminous classes and between bituminous and sub-bituminous classes. Should an agglomeration test, now being investigated, prove to be more satisfactory, it may be substituted for the agglutinating test.

TABLE II. SYMBOLS FOR COAL BY GRADE WITH ANALYSES EXPRESSED ON THE BASIS OF THE COAL AS SAMPLED

Ash[a]		Softening Temperature of Ash[b]		Sulfur[a]	
Symbol	Per cent, inclusive	Symbol	Deg. Fahr., inclusive	Symbol	Per cent, inclusive
A4	0.0 to 4.0	F28	2800 and higher	S0.7	0.0 to 0.7
A6	4.1 to 6.0	F26	2600 to 2790	S1.0	0.8 to 1.0
A8	6.1 to 8.0	F24	2400 to 2590	S1.3	1.1 to 1.3
A10	8.1 to 10.0	F22	2200 to 2390	S1.6	1.4 to 1.6
A12	10.1 to 12.0	F20	2000 to 2190	S2.0	1.7 to 2.0
A14	12.1 to 14.0	F20 minus	less than 2000	S3.0	2.1 to 3.0
A16	14.1 to 16.0			S5.0	3.1 to 5.0
A18	16.1 to 18.0			S5.0 plus	5.1 and higher
A20	18.1 to 20.0				
A20 plus	20.1 and higher				

[a] Ash and sulfur shall be reported to the nearest 0.1 per cent by dropping the second decimal figure when it is 0.01 to 0.04, inclusive, and by increasing the percentage by 0.1 per cent when the second decimal figure is 0.05 to 0.09, inclusive. For example, 4.85 to 4.94 per cent, inclusive, shall be considered to be 4.9 per cent.

[b] Ash-softening temperatures shall be reported to the nearest 10 F. For example, 2635 to 2644 F., inclusive, shall be considered to be 2640 F.

The factors discussed above have all been of primary concern in the development of the classification by rank, but many of them have a direct bearing upon the classification of coal by grade. From the standpoint of use the essential factors are calorific value, ash and sulphur content, and ash-softening temperature, upon which the specifications for classification of coal by grade have been based. Further correlation of scientific data with the uses of coal and commercial practice are under way. Specifications for screen size, resistance to breakage, caking properties and other factors important in the use of coal for special purposes are under consideration by the committee.

The importance of adopting suitable names for the various classes and groups of coal was recognized by assigning this important subject to a technical committee on nomenclature. This committee consulted many authorities and gave careful consideration to the various names that have grown up in commercial usage and in the literature relating to coal. On the basis of this investigation the names given in the columns headed "Class" and "Group" in the table were recommended. Most of these names are well established by long usage and therefore will not lead to any confusion in the use of the new classification.

Turbine Vibration Through Defective Coupling

W. E. WARNER.

TURBINE VIBRATION is often caused through defects in the coupling between it and its driven load. In one instance a turbine gave trouble through vibration. On examination the flexible claw coupling between the turbine and the generator was found to be worn and showed signs of hammering. The clearance between the faces had increased and shoulders had developed 1/16 in. high. After the coupling had been readjusted the set ran smoothly. In another instance a pinion shaft was driven from the main turbine shaft through a flexible claw coupling. The pinion shaft was secured by two keys. The turbine started to vibrate, the coupling ran noisily and the main bearings heated up. On examination the coupling was found to have been chattering through its being a bad fit on the shaft and the pinion shaft itself was found to be cracked where the keyways were cut. The corners of the keyways had been left sharp instead of having been rounded off, this had led to a concentration of stress which finally caused cracking.

Economies Effected *by Use of* RETURN TRAP

In This Case Study, the Computations Necessary for Making Comparisons Between Different Systems of Feedwater Pumping in a Simple Boiler Heating Plant Are Indicated. By Leo P. Flood, Mechanical Engineer, Nason Mfg. Co.

REALIZATION of important fuel saving by the use of the return trap has not been fully appreciated by many plant executives and operating engineers. Yet, this system by which condensation is returned to the boiler while it is still hot, has been recognized by users as an efficient means of effecting large power economies. The following information will reveal interesting facts that will prove enlightening to many readers.

When operating a boiler at 125 lb. pressure, it requires more fuel to heat 3 lb. of make-up water from 45 deg. F. to boiler temperature, than it does to evaporate 1 lb. of water at boiler pressure and temperature. Therefore, if economy of operation is to be attained, it is extremely important to conserve the heat in the condensate and to use as little make-up water as possible. The use of the return trap for feeding the water to the boiler accomplishes both of these objectives, as well as having many other incidental advantages.

To make a comparison of the savings obtained by use of the return trap with that of the ordinary methods of returning condensate, and feeding make-up to the boiler by means of an open hot well or receiving tank and a boiler feed pump, let us consider a plant where the entire boiler load is used in heating coils in a dry kiln. In Fig. 1, an elementary layout of such a plant is shown. The work of the boiler has been divided into two parts in order to show clearly that it has two tasks to perform. First, to heat the feedwater to boiler temperature. Second, to evaporate this water. In the figure referred to, A is the main boiler for evaporating only. B is the auxilary boiler for heating the feedwater to boiler temperature. C is an ordinary boiler feed pump. D is the dry kiln heating coil. E is a non-return steam trap, and F the hot well. Since a comparison is drawn between two methods of handling the condensate, those factors which are equal in both cases, such as drop in pressure in pipe lines, are omitted, so as to simplify matters.

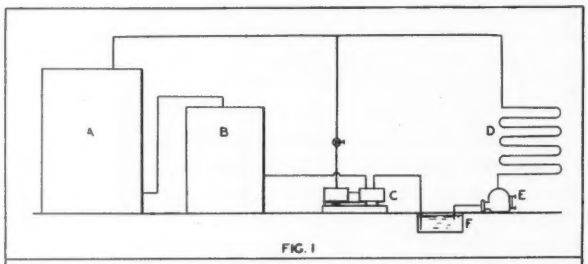


FIG. 1

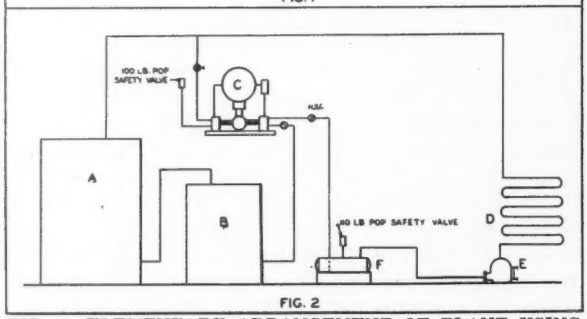


FIG. 2

FIG 1. ELEMENTARY ARRANGEMENT OF PLANT USING PUMP FOR BOILER FEEDING

FIG. 2. ARRANGEMENT OF PLANT USING RETURN TRAP FOR BOILER FEEDING

Boiler A is producing dry saturated steam at a pressure of 125 lb. per sq. in. and it has a capacity of 100 hp. The boiler produces 3880 lb. of steam per hour under these conditions; 76 lb.[4] of this is used to pump the water back to the boiler; the remainder of the steam is condensed in the coil and the condensate is at a temperature of 350 deg. F. This is discharged to the hot well through a non-return trap without the loss of live steam. In this free discharge, part of the water flashes into steam. In the case we are considering, this is 580 lb. or about one-sixth of the total water.[1] The remainder of the condensate is cooled to 212 deg. F., the temperature corresponding to atmospheric pressure. This re-evaporation, or flash as it is commonly called, is caused by the fact that the water in the trap at 125 lb. pressure is at a temperature of 350 deg. F., and that when the pressure is reduced to atmospheric, the temperature condition is unstable. In order to restore a stable condition some of the heat in the condensate is used in evaporating a portion of the water until the balance is cooled to 212 deg. F. which is the stable condition at atmospheric pressure. The steam which evaporates as well as the heat which it contains is a total loss from the system and must be replaced with make-up water at 45 deg. F. The mixture of the hot condensate and the cold make-up water is taken by the pump and delivered through the

[1]The portion of the condensate, which flashes into steam, is determined by equating the total heat in the water at the high pressure to the sum of the heat units in the water and in the steam at low pressure. $mq_h = (m - x)\, q_e + x\, i_e$ where m=original weight of water, q_h=heat of liquid at high pressure, x=weight of flash steam, q_e=heat of liquid at low pressure and i_e=heat of vapor at low pressure.

auxiliary boiler to the main boiler. In the auxiliary boiler, the feedwater is heated to 350 deg. F. or boiler temperature. This heating consumes 70.8 lb. of coal and requires a boiler capacity of 20 hp.

Let us now consider the other method where the system is closed and a return trap is used to return water in the boiler. This is shown in outline in Fig. 2. As in the first case the main boiler A produces 3880 lb. of steam per hour at 125 lb. per sq. in. pressure; 19 lb.[4] of this is used in the return trap C, or only one quarter of what was used in the boiler feed pump. The remainder of the steam 3861 lb. is condensed in the coil D. This is discharged as before through a ball float steam trap,[2] E, into a closed receiver F, which is equipped with a pop safety valve set at 110 lb. As in the previous case, part of the condensate (42.5 lb.) flashes into steam and the remainder cools to about 345 deg. F., the temperature corresponding to 110 lb. pressure. (Although part of this flash steam is recondensed to make up for radiation losses, in order to simplify our computations, let us assume it all escapes through the safety valve.) From the receiver, the water passes to the return trap C, which is located about 6 ft. above the water line of the main boiler and is maintained, by means of a pop safety valve, at 100 lb. pressure when in the filling position. Again part of the water (30 lb.) flashes into steam because of the reduction in pressure. This too may be assumed to escape through the pop safety valve with which the trap is equipped. When the trap tank is filled it tilts, closing the vent connection, on the outlet of which the safety valve is connected, and opening the steam valve connected to the boiler. This in effect makes the trap tank part of of the boiler and since the water in the trap is 6 ft. above the boiler water line, it drains by gravity through the auxiliary boiler B, where it is heated to boiler temperature, thence to the main boiler. In this case too, make-up water must be added to take care of the flash steam which we assumed escaped through the two safety valves. This amounts to 91.5 lb. which is heated along with the condensate to 350 deg. F. in the auxiliary[3] boiler. In the case of the closed system with return traps used, a total of 9 1/3 lb. of coal must be burned in the auxiliary boiler which is about 2⅝ hp. capacity.

In the resumé of computations are shown the total heat, the weight of water and steam and the pressure conditions at the various points in each system. The net results of the analyses of these systems is that when the return trap is used rather than the pump, a fuel saving of 17 per cent is effected under the conditions specified here.

With a boiler capacity of 100 hp. with an efficiency of 70 per cent and a fuel with a heating value of 13,500 B.t.u. per pound which costs $4.40 per ton delivered, an annual saving of $976.00 may be made when the plant is operated 24 hr. per day, 300 days per year. The cost of the pipe, traps, receiver, safety valves, etc., including the installation for this plant was $483.60.

RESUME OF COMPUTATION

Data — Operating Pressure 125 lb. per sq. in.

Capacity — 100 Horsepower

Properties of Steam

Pressure	Heat in Liquid	Heat in Vapor	Latent Heat
125 lb.	324 B.t.u.	1193.7 B.t.u.	869.7 B.t.u.
110 lb.	314.9 B.t.u.	1192.0 B.t.u.	877.1 B.t.u.
100 lb.	308.4 B.t.u.	1190.7 B.t.u.	882.3 B.t.u.
0 lb.	180.0 B.t.u.	1151.7 B.t.u.	971.7 B.t.u.

Results of Computation
Using Return Trap System

	Weight of Water or Steam in Pounds	Gage Pressure in Pounds per sq.in.	Heat Content in B.t.u.
Leaving boiler	3,880	125	4,640,000
Used in Return Trap	19	125	22,700
Left for Coil	3,861	125	4,617,300
Used in Coil	0	125	3,360,000
Left at Non-return Trap	3,861	125	1,256,300
Lost in:			
Flash to 110 lb.	42.5	110	50,800
Receiver	3,818.5	110	1,206,500
Flash to 100 lb.	30	100	35,721
Return Trap	3,788.5	100	1,170,779

Heating this to boiler temperature — 3,788.5 x 15.6 = 59,000 B.t.u.

Make-up water to be added and heated to boiler temperature — 91.5 x 311 = 28,500 B.t.u.

(Feed Water Temperature 45 deg.) — 87,500 B.t.u.'s to be added in auxiliary boiler.

Using Boiler Feed Pump

	Weight of Water or Steam in Pounds	Pressure in Pounds per sq.in.	Heat Content in B.t.u.
Leaving boiler	3,880	125	4,640,000
Used in Pump	76	125	90,800
Left for Coil	3,804	125	4,549,200
Used in Coil	0	125	3,300,000
Left at Non-return Trap	3,804	125	1,249,200
Lost in:			
Flash to 0 lb.	580	0	667,000
Hot Well	3,224	0	582,200

Heating this to Boiler Temperature — 3224 x 144 = 464,000

Make-up water to be added and heated to boiler temperature — (Feed Water at 45 deg. F.) 656 x 311 = 204,200

Added in Auxiliary Boiler — 668,200 B.t.u.'s

Comparison and Conclusion

	Return Trap System	Pump
Heat available for useful work	3,360,000	3,300,000
Heat added in main boiler	3,375,000	3,375,000
Heat added in Auxiliary boiler	87,500	668,200
	3,462,500	4,043,200
Efficiency of System	3,360,000 / 3,462,500 = 97%	3,300,000 / 4,043,200 = 83.2%

Saving by using Return Trap System — 97 / 83.2 x 1.00 = 1.17

1.17 - 1.00 = 17% saving

Since the saving by the use of the return trap was $976.00, this is an annual return on the investment of 200 per cent.

The case considered is a type of boiler plant where all of the steam is used for heating at boiler pressure. A similar analysis could be made of a plant where there are both high and low pressure returns and a worthwhile fuel saving would be made. Since the conservation of heat by use of the return trap system increases the amount of useful heat added in the boiler, it increases the plant capacity. Traps used for this purpose have in many cases obviated the expenditure of large sums for additions to the boiler plant.

[2]The trap in this case should be a trap suited for a maximum pressure of 125 lb., but equipped with a 15-lb. valve since this is the pressure differential between the inlet and outlet.

[3]This make-up water may be introduced by a steam injector.

[4]The boiler feed pump was assumed to have a steam cylinder twice the diameter of the water cylinder. This would give a steam consumption in cubic feet four times the volume of the water pumped. This is equal to 76 lb. In the return trap the steam used is equal to the volume of the water pumped which reduced to pounds gives 19.

Scavenging of Two-Cycle Diesel Engine

History of Sulzer Accomplishments During Past 30 Yr. Shows What Research Has Accomplished

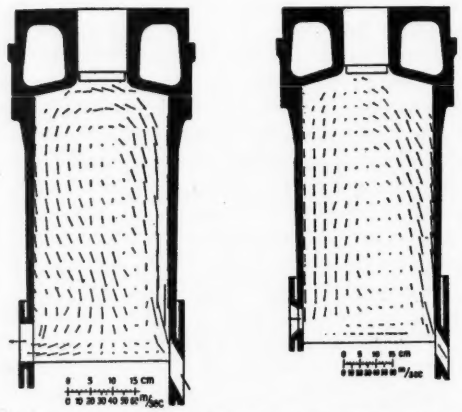


FIG. 1. PATH AND VELOCITY OF SCAVENGING AIR IN AN OLD (LEFT) AND NEW (RIGHT) CYLINDER DESIGN. VECTORS ARE PROPORTIONAL TO VELOCITY. MODELS WITH LIGHT SILK RIBBONS, PITOT TUBE TRAVERSES, SMOKE, SAWDUST AND BURNING MAGNESIUM RIBBON ARE USED IN DETERMINING DATA PLOTTED ABOVE. CYLINDER CONDITIONS ARE EXTREMELY SENSITIVE TO CHANGES AND ARRANGEMENTS OF PORTS AND THE POSITION OF THE PISTON

IT IS EVIDENT that the efficiency of a two-cycle Diesel engine depends to a great degree on the excellency of the scavenging, since bad scavenging gives a low mean indicated pressure and, consequently, a high weight and high price per horsepower. With insufficient scavenging the air charge is comparatively poor in oxygen, so that the combustion is incomplete and the fuel consumption high. The lubricating oil becomes more contaminated, so that its lubricating qualities are reduced, thus leading to increased wear in the pistons and cylinder liners. Renewals are then more often required. The mean temperatures in the cylinder and the heat stresses in the surfaces in contact with the hot gases, are also greater.

Every improvement in the scavenging consequently leads to an improvement in the engine, or in its efficiency, in several directions. This is why inventors are so active in this field and why the leading firms building two-cycle Diesel engines are incessantly striving to improve the scavenging. In this respect it is particularly interesting to follow the development of the Sulzer scavenging, since it was an entirely new principle when first brought out, and it has been particularly helpful in allowing the two-cycle principle to be applied to large Diesel engines.

Figure 2 shows diagrammatically the system of scavenging first used. It was introduced in 1905. At the end of the expansion stroke the piston uncovers a row of exhaust ports through which the products of combustion escape. It was successfully used in a large number of engines and proved satisfactory in service. Investigations of the scavenging effect showed, however, the existence below the inlet valves, during the scavenging process, of dead spaces which were only partly cleared of the products of combustion. The endeavor to effect improvements led to the study of other methods.

Figure 3 shows the Sulzer scavenging, developed in 1910. The cylinder cover contains only the centrally arranged fuel injection valve, which may be combined with the starting valve. Scavenging air flows into the cylinder through inlet ports arranged opposite to the exhaust ports. This system allows after-charging, that is, the cylinder may be charged at the beginning of the compression stroke with a greater quantity of air than the cylinder of an ordinary two-cycle engine of the same dimensions, without any additional work being required.

A further development of this method of scavenging is shown in Fig. 4. Here the positively controlled

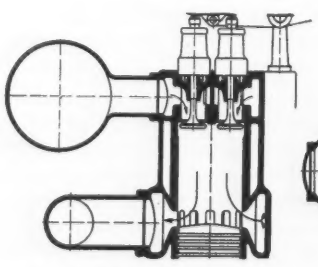


FIG. 2. TWO-STROKE ENGINE WITH SCAVENGING VALVES IN THE CYLINDER HEAD

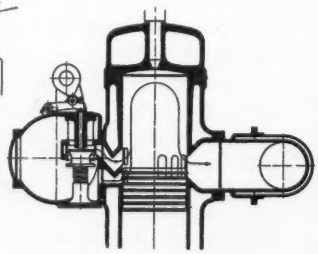


FIG. 3. FIRST DEVELOPMENT OF THE SULZER SCAVENGING SYSTEM IN 1910

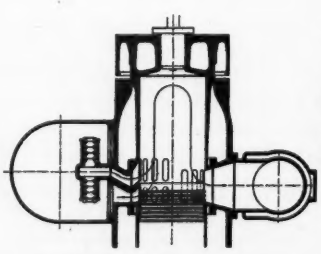


FIG. 4. TWO-STROKE ENGINE SCAVENGING SYSTEM WITH AUTOMATIC VALVES

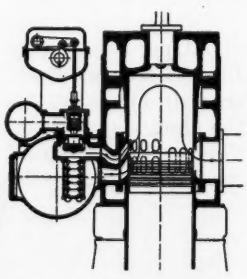


FIG. 5. TWO-STROKE ENGINE WITH SCAVENGING AND SUPERCHARGING SYSTEM

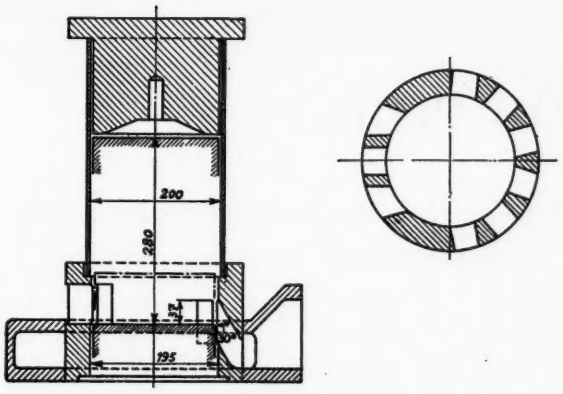


FIG. 6. EXPERIMENTAL SCAVENGING MACHINE WITH MOVING PISTON. THE CYLINDER IS FILLED WITH CO_2 GAS, SCAVENGED AND THE CONTENTS ANALYZED

double-beat valve is replaced by a row of automatic valves. The elimination of the valve gear brought about a further simplification of the whole engine.

This arrangement of the scavenging is also used for double-acting Diesel engines. Here three rows of ports are provided, one above the other. The middle row remains permanently in connection with the scavenging air receiver, while the top and bottom rows are each controlled by automatic valves. In certain cases the middle row of inlet ports is omitted, thus leading to a simplification of the whole design. Here the total quantity of scavenging air is led into the cylinder through automatic valves of particularly light construction and of ample size.

For engines intended for covering peak loads in central stations, the scavenging process with supercharging, shown in Fig. 5, was developed. The first part of the process remains the same as before, but after the cylinder has been charged with air up to the scavenging air pressure, a positively controlled valve opens, and compressed air flows into the cylinder through the upper row of ports. This valve remains closed for the rest of the time and admits only the quantity of additional air required for supercharging. In this manner the cylinder may be highly supercharged and its output correspondingly increased. The supercharging air is generally supplied by a low-pressure compressor arranged over the scavenging pump and driven from it. The compressor can be throttled when not required and then runs light.

Performance of the engine depends upon the effectiveness or efficiency of the scavenging. Variations in the performance of designs, the effect of ports and port angles, etc., can be determined experimentally, although no method of research can allow all the factors influencing the scavenging to be investigated simultaneously. The whole problem must consequently be divided up and tackled from different sides.

Direct measurements in the output of the engines does not always give the desired result because the output is also influenced by combustion which depends upon the atomization of fuel as well as many other factors. Investigation of cylinder charge by means of gas samples taken while the engine is working is one of the most valuable means of determining the efficiency of scavenging because this isolates it from other factors.

Analysis of the test gas samples taken from a two-cycle engine at full load during the compression stroke gave a purity of charge (ratio of air to gas) of 96 per cent to 97 per cent. Similar results were obtained from the analysis of samples taken from a double-acting engine of 600 mm. bore and running at 187 r.p.m., when the purity of the charge at full load was found to be 94 per cent to 97 per cent.

Need for Further Improvement Questionable

It is perhaps possible to effect still further improvements in the scavenging, but it is also questionable whether this is at all necessary. A two-cycle engine working normally with a mean indicated pressure of 7 atm. (about 100 lb.) is already heavily loaded. If the mean pressure is still further increased, the heat stresses will also increase to such an extent that cracks may develop in time in the piston, cylinder cover and liner. A further increase in the normal mean pressure would, in consideration of the heat stresses, only be possible by supercharging, a method which has, however, nothing to do with the scavenging.

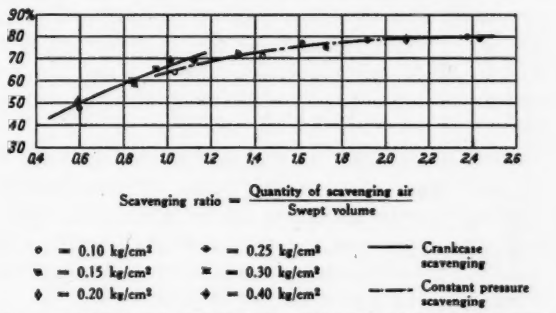


FIG. 7. PURITY OF CYLINDER CHARGE SHOWN BY TEST RESULTS OBTAINED WITH PORTS ARRANGED AS IN FIG. 6

So long as the available materials and the design of the engine do not allow the normal mean indicated pressure to be increased beyond 7 atm. in a non-supercharged two-cycle engine, there is no use trying to improve the scavenging in order to obtain still higher mean pressures than those which have already been found to represent a safe figure.

Overhead Should Be Limited

Nevertheless, it is, of course, desirable to obtain a temporary overload. The Sulzer scavenging described above, giving 7 atm. normal mean pressure, would alone be sufficient to give 20 per cent overload, corresponding to a mean pressure of 8.4 atm. (about 120 lb.) But, in this connection, it must not be forgotten that there is a danger of a Diesel engine in service being occasionally heavily overloaded for too long a time, especially if it is attended by an unskilled staff.

The results obtained show that the scavenging as used today is amply sufficient for all the requirements met with in practice. Further improvement may possibly be inadvisable. In any case, an improvement could only be effected at the sacrifice of simplicity of construction, introducing complications which would not be justifiable, since the advantages gained would probably, in any circumstances, be only small, and the necessary alterations in design would adversely affect the overall economy and the simplicity of the engine.

Readers' Conference

Maintenance of Chain Conveyors

THAT THE LINKS and sprockets of chain conveyors are kept clean and well lubricated, worn or damaged links and sprockets are replaced at once, so as to relieve the adjacent links and sprockets from avoidable wear, are important features of operation. If either the chain or the sprockets become worn and out of pitch, wear will be caused on the other unit engaging with it, so badly worn sprockets will cause severe wear on a new chain and vice versa. The sprocket teeth will wear more than the chain links as they engage more frequently. It is therefore advisable that they should be made of wear-resisting metal, particularly where gritty material is being handled. The principal causes of wear are dirt, lack of lubrication and misalinement. Dirt causes wear for, if permitted to collect, it will be ground between the teeth and the links, and as part of the dirt will be gritty and abrasive wear will obviously be caused.

If a chain is not kept properly lubricated the rivets will cause wear on the links. When a chain is running on two sprockets out of alinement, wear of both the chain and the sprockets will result. Once wear starts it will continue, the drive will give trouble when working and efficiency will be lost.

Particular care should be taken to see that perfect alinement is maintained between the two sprockets. Wear on the inside of the side bars indicates sprocket interference, showing that re-alinement of the sprockets is necessary. Where the rollers or cross barrels are seen to be wearing rapidly, the sprockets should be tested for chain fit, as some of the sprocket teeth do not properly fit the links. These conveyors should be given a weekly cleaning, the chain links and the sprockets should be cleaned with a stiff bristle brush and kerosene. Any moving parts in the chain should then be lubricated. For this purpose a thick machine oil is used with much success, or a good lubricant can be made from two-thirds ordinary engine oil and one-third steam engine cylinder oil. Where the surrounding atmosphere is very gritty, an excellent method is to lubricate the links with ordinary machine oil, and then give them an external coat of grease which will serve to exclude dirt from the moving surfaces.

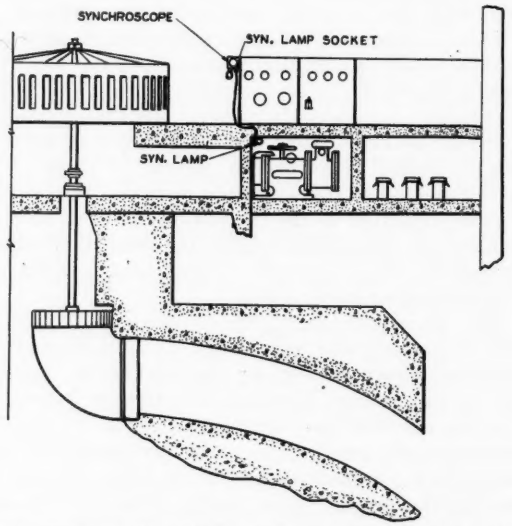
Two causes of sprocket misalinement are movement of the foundations to which they are fixed, or bearing wear and readjustment of the bearings. As the latter is constantly occurring, frequent checking of the alinement is advisable. Frequent inspection of the whole drive is also necessary. This will show if the chain is fouling any stationary object at any point. Any wear on the links or sprockets will be detected in time so that a timely adjustment can be made which will prevent much wear.

Herts, England. W. E. WARNER.

Use of Remote Synchronizing Lamp

A HYDRO-ELECTRIC PLANT had its switchboard located at a rather remote point from the governors controlling the wheels. These governors were either automatic or electrically controlled from the board. However when starting up they were manually operated from the governor room.

This plant was tied in with a steam electric plant. Originally when phasing in with the steam plant the operator in the governor room would set the governor in an approximate position and run up to the switchboard to check up on his adjustment. Often it required a number of trips up and down to get the synchroscope rotating at a correct speed for synchronizing.



ARRANGEMENT OF PLANT SHOWING LOCATION OF LAMP

Much of this trouble was eliminated by extending one of the synchronizing lamps to the governor room. In this way the operator could stay at his controls and quickly get the unit rotating at the correct speed for phasing.

Waterville, Maine. HARRY M. SPRING, JR.

Get Ready for Cold Weather Now

DURING the warm summer months it is always difficult to make ourselves realize that in a few months it will be cold again. Most of us dislike and dread winter and that is one reason why we often are not ready for it when it puts in its appearance.

But, just the same, like it or not, now its the time to get ready for winter. Compel yourself to do it. I suggest that you go around your establishment with a pencil and pad and make memoranda of what should be done now so as to be ready when cold weather is

here. Do the work as soon as possible. When winter arrives you will experience that peace of mind and happiness, always so pleasant to experience after a good deed is well done.

Perhaps I can assist by making some suggestions. Take boilers, for example. Are your boilers in good condition? Statistics prove that workers are in greater danger in winter than in summer because boiler explosions are more numerous in December, January and February than in the other months.

Now, too, is a good time to modernize old boilers. Clean them thoroughly. Make them better than when they were new by installing modern baffle walls in them. A first-class leakless baffle wall is a much more important economy factor than is generally realized. Leaks in the setting should also be stopped. Check over the grate bars, the stoker, the economizer, the feedwater heater, the feedwater regulator, the water column, the gage glass, etc.

Perhaps you use exhaust steam during the winter months but not during the summer months. If so, put the exhaust system in shape. Look over the back pressure and control valves. Steam traps usually give more trouble in winter than in summer. So do pumps and receivers. Give them all a careful test and if they need repairing, repair them.

How about the roof? Is it insulated? If not, and if you have never investigated the benefits that result from an insulated roof I suggest that you investigate. For instance, more heat is generally lost through the roof than through the walls of a building owing to the fact that warm air always goes upward and contacts the ceiling. If the ceiling is cold and not insulated, good-bye valuable heat!

To insulate an old roof is not as difficult as may be believed. It is not necessary to remove the old roofing. Simply make the roof smooth and clean. One well known and much used formula for old roofs as well as new is this: A layer of pitch or asphalt, plus a layer of cork board, plus another layer of pitch or asphalt. That's all that is necessary. You then have a durable, leakless, heat-proof and cold-proof roof.

Some woodwork needs a coat of paint once every year—especially wood that is exposed to sunlight every day. Clean out the water leaders from the roof. Be sure that all stuffing boxes are properly packed. Inspect all valves. Inspect insulation on hot pipes. If there is a sprinkler system in your plant, be sure that it also is in good working order. There are more fires in winter than in summer. Vacuum lines, broken window panes also are to be looked after. And so forth. By doing these important jobs now greater efficiency and economy will result during the winter months. Besides, it is easier to do them now than later on when the equipment is needed. The time to do these things is when the plant load is lowest and that time is usually during the warm summer months. Next winter the same work may cost ten times as much or even more. It often is expensive to carry full load and do certain repair jobs simultaneously. Sometimes it cannot be done at all without extraordinary expense and inconvenience.

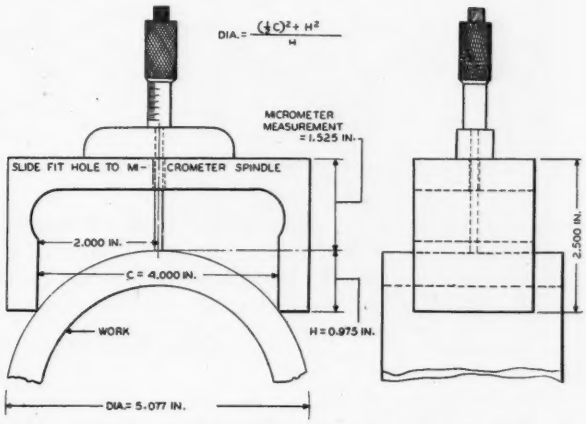
Newark, N. J. W. F. SCHAPHORST.

Depth Micrometer Used to Determine Diameter

WHEN IT BECOMES necessary to obtain the exact dimensions of thrust shells, as they are found in the end bearings of rubber mill rolls, printing press rolls, etc., which are usually about one-third of a round bushing, the following device designed by myself is quite convenient.

The device consists of steel, hardened for best service, and finish ground to the dimensions shown. It is used in connection with a depth micrometer and a simple formula, given below.

As designed, it can be used with accuracy for measuring diameters from 4 to 6 in. With less accuracy it will measure diameters up to 16 in., but it is advisable to make the gap, C, 6.000 in. or more for the larger diameters and to increase the other dimensions proportionally.



FINDING THE DIAMETER OF CIRCULAR WORK WHERE THE CENTER IS NOT ACCESSIBLE

To use the device place it on the work to be measured, adjust the depth micrometer until its spindle just touches the work. Take the reading to the third decimal place and subtract this reading from the gage height which is 2.500 in. on this gage, leaving the remainder H. Constant remains C which is 4.000 in. Now apply the formula:

$$\text{Diameter} = \frac{(\frac{1}{2}C)^2 + H^2}{H};$$

Example:

Reading as obtained with the depth micrometer is 1.525 in.

Gage height $2.500 - 1.525 = 0.975 = H$;

$(\frac{1}{2}C)^2$ of the formula remains constant $= 4.000$;

$$\frac{4.000 + 0.975^2}{0.975} = 5.077 \text{ in.} = \text{diameter of work.}$$

Highland Park, Mich. PAUL C. BRUHL.

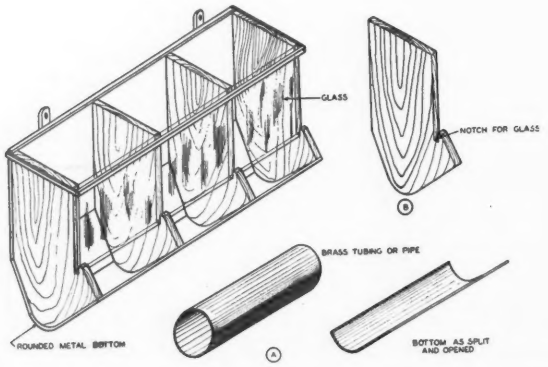
Visible Small Ware Container

MUCH MAY BE SAID in favor of a visible homemade small hardware container such as I have made for use over the plant maintenance bench and shown herewith in the sketch.

Little effort is required to make the container from

material at hand in the plant. Use ¾-in. board and a bit of sheet iron or brass or if preferred the bottom section can be made from a piece of large size brass pipe split lengthwise and opened as indicated in the detail sketches, A. The partitions are made as at B, and the front of the container is of heavy glass; I purchased a piece of windshield from an auto wrecking yard for mine.

The supply of small parts that are constantly needed for maintenance are always in view and kept



DETAILS OF A HANDY BIN TO BE USED FOR SMALL PLANTS

orderly, and are self feeding to the worker's fingers, when the supply is low the curved smooth interior of the bottom is easy on the finger tips and the last piece is quickly and easily scooped out.

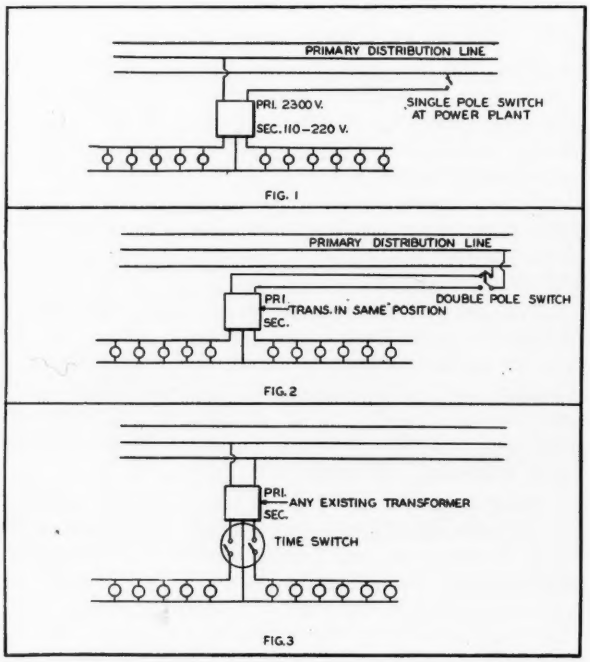
Concord, N. H. CHAS. H. WILLEY.

A Street Lighting Problem from the Standpoint of Economy and Safety

IN SOME OF THE SMALLER municipal systems a street lighting circuit such as is shown in Fig. 1 is used. This system is outmoded and in fact leads to several dangerous conditions. There is only one switch (at the power plant) and when it is opened the lights are out. The return wire, however, is hot to ground and to two of the other wires making it dangerous to work on even with the switch in the "out" position. Then too if there happens to be a ground leakage on the return wire it will make the secondary alive but probably with reduced voltage. The original idea was to do away with one extra wire by using the regular primary house service for part of the lighting distribution layout.

The question is, "What could be done to make this system over so that it would eliminate all dangerous conditions?" There are several ways in which it might be done. One would be to modernize the whole system and put in a series lighting system. This method would cost an excessive amount of money. Another way, while probably costing the least, would be to string another wire alongside of the present system wire and put in a double pole switch on each line at the power house. This circuit is shown in Fig. 2. When the switch is open the linemen can work without fear on the system as everything is dead and certainly the hazard of the existing system would be eliminated. This would not require the removal of any of the existing transformers, etc., and the present lights could be used as they are.

There might be some trouble in stringing the extra primary wire because of lack of room on the present cross arms and also due to many trees. Probably the best way would be to use some sort of a time switch. The switch could be installed in the primary line near



THREE METHODS OF CONTROLLING STREET LIGHTING SYSTEM

the distribution transformer of each section of street lights. The primary taps could be taken off the main lines eliminating the return wires of Fig. 1. With primary switching the time clock would have to be connected up with an oil switch which would be expensive and unnecessary. The time switch could be placed in the secondary of the lighting distribution transformer and using a low voltage switch. If the transformer needed repairs the primary fuses could be withdrawn. This scheme would make it easy to repair any of the street lights as everything would be cut off with the time switch. A still better way would be to use the distribution transformers of the house lighting system and connect on the street lights to the secondary system wherever it was practical. The old transformers formerly used on the lighting circuit could be used in other parts of the system or sold.

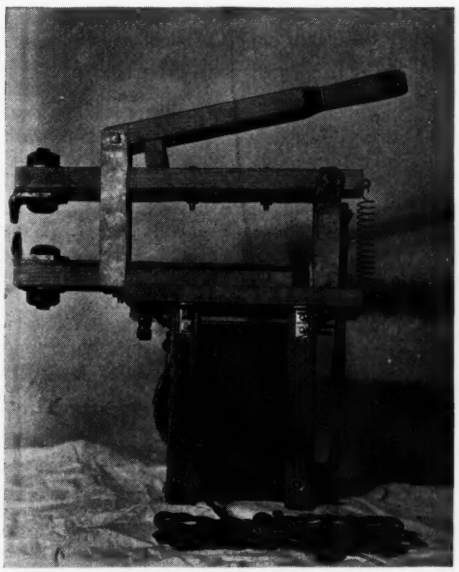
In some cases the street lighting system is metered. The original layout would have the meters located at the power house in the primary circuit. In the new system a small meter could be included in the same case as the time switch. Many utilities furnish street lighting on a flat rate basis and consequently meters would not have to be taken into consideration. The layout is shown for the time switch arrangement in Fig. 3.

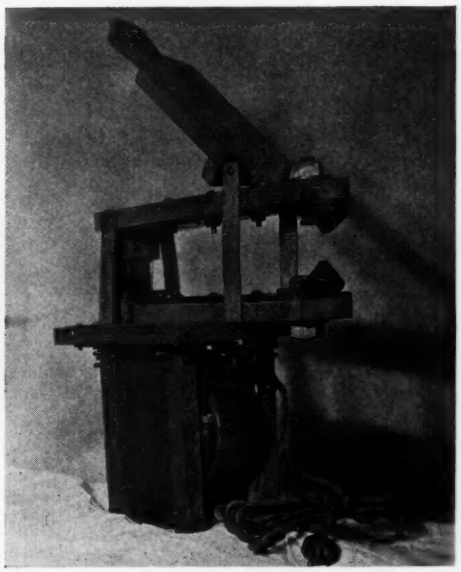
Waterloo, Wis. K. B. HUMPHREY.

Building a Spot Welder

THE WELDER described here has proved very useful around the company's workshop for repairing refrigerator shelves, oven shelves and for many other odd jobs which would otherwise require expenditures for brazing.

A core from a 200 va., 2200 v. to 110 v. potential transformer was used on which 90 turns of No. 8 copper wire were wound for the primary. Enameled or single cotton covered wire is necessary in order that the available winding space be utilized to full advantage. The author used old No. 8 secondary, burning off the heavy insulation and reinsulating it with friction tape, running the tape lengthwise of the wire and folding it around the wire till its edges adhered together. This is a pretty tedious job so unless the reader desires to spend time rather than money it will be worth while to purchase new magnet wire for the purpose.





Two views of the house made spot welder showing method of construction. The frame is made of wood. The electrode arms are kept apart by the pull of the coiled spring. The electrodes were made from some scraps of ¼ by 2 in. bus bar.

For the secondary or welding current winding one turn or layer on top of the primary coil is all that is used. This winding consists of nine 2½ in. by 24 in. copper sheets (cut from an old wash boiler). This gives a secondary copper cross section of about (¼ in. by 2½ in.) or slightly better than ½ sq. in.

As will be seen from the photographs four oak slats with four bolts hold the core together and serve as a mounting for the top (7 in. by 10 in.) through which the secondary is passed. Two oak arms serve as supports for the electrodes which were cut from some scraps of ¼ in. by 2 in. copper busbar.

A lever arm with convenient handhold allows considerable pressure to be applied to the weld. A coil spring keeps the electrodes apart normally. Two binding posts mounted under the top and connected in series with the primary allow for fusing. A flexible lamp cord makes it convenient to plug into a circuit suitably wired and fused for 25 amperes.

On test the welder melted the head of a ½ in. machine bolt and drew a primary current of 20 amperes. Roughly, therefore, the secondary current was in the neighborhood of (20x20) = 1800 amperes.

On light thin metal a quick touch of the electrodes usually makes a satisfactory weld and avoids the danger of burning a hole. On heavy work care must be exercised not to exert too much pressure at any time otherwise the metal will be flattened noticeably. The weld is not completed until the metal is white hot and at the melting point. Some difficulty is encountered in welding galvanized metal, in that the galvanizing must be removed, otherwise the zinc coats the iron with oxide and prevents the pieces from joining. Excellent results are obtained on black iron such as is often found inside the cheaper electric range ovens, and which in our experience, often comes loose on oven doors. These are of course only a few of the many uses to which the welder will be put once it becomes part of the company's workshop equipment.

Sparta, Wisconsin. VERNON W. PALEN.

Care of Felt Washers

FELT LUBRICANT retaining washers must be kept in first-class condition, for if they harden or wear they will permit the lubricant to escape and they may cause any revolving metal parts in contact with them to wear. A good washer should act as a reservoir for the lubricant.

Before fitting they should be soaked in hot lubricating oil of a consistency similar to that which will be used in service. The washers should then be fitted. Periodically the washers should be examined. They should be removed from the shaft and cleaned by soaking in kerosene to remove any grit or sludge which may have collected in the felt. They should then be soaked in hot lubricating oil. If sound they may be replaced, if found to be worn or torn they should be discarded and new washers fitted.

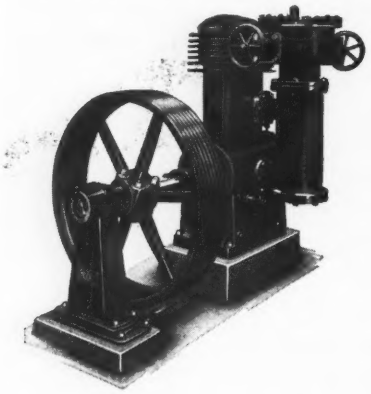
Herts, England. W. E. WARNER.

New Equipment

Freon Compressors

DESIGNED PARTICULARLY for air conditioning work and ranging in size from 15 to 300 t. refrigerating capacity, a new line of enclosed-type Freon compressors is announced by the Frick Co., Waynesboro, Pa. These compressors are all furnished with twin vertical cylinders, single-acting and with plate type valves for both the suction and discharge.

Each machine is fitted with a force-feed lubricating system, the oil pump being located in the bottom of the crankcase and driven by

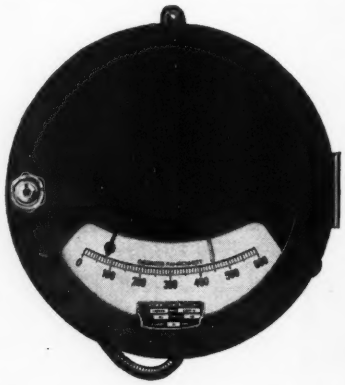


an internal chain from the crankshaft. The oil coming back with the suction gas is separated by the large trap beneath the manifold, and is returned to the crankcase. Either V-belts or direct synchronous motor drives are used as standard. All except the two smallest machines have outboard bearings beyond the flywheels.

Brown Indicating Thermometer Controller

USE OF MERCURY switches to eliminate open make-and-break contacts controlled by the pointer, is a new feature of an automatic control indicating thermometer announced by The Brown Instrument Co., of Philadelphia, Pa. In this new controller, every six seconds a motor-driven control table determines the location of the pointer in reference to the control setting, and tilts the mercury switch from one side to the other if the temperature has changed.

With this system, the measuring mechanism is free to position itself, unhampered by the control mechanism. The making of control contacts is not dependent upon friction, because the switch is positioned with a positive action by the electric motor. Contacts are unaffected by vibration because the mercury switch is mechanically locked in



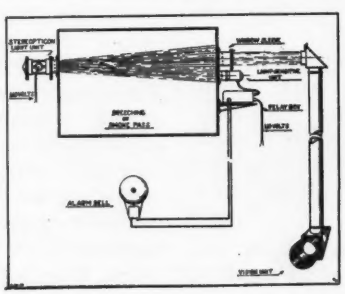
place until a different position is required.

This control mechanism is adaptable to one-, two-, or three-contact control (or signalling) systems.

Brown indicating control thermometers are equipped with the same measuring system and control mechanism supplied with Brown recording control thermometers. This type of instrument has given excellent service in installations where it was desirable to measure temperature at a distance up to 200 ft. and at the same time control the temperature or signal an alarm when the temperature gets beyond certain limits.

Eclipse Photoelectric Smoke Detectors

BY ADDING photoelectric and relay equipment to the Eclipse visual smoke indicator which for years has been an effectual aid in eliminating smoke, T. W. McNeill Engineering Equipment Co., Chicago, Ill., has designed smoke detecting systems that are extremely flexible in their application. By this means the relay may be used not only to give alarm by ringing a bell, sounding a horn or lighting a lamp when the smoke density has reached the prohibited stage, but to operate one or more indicators or recorders at any desirable location about the plant.



Improved Surge-Crest Ammeter

AN IMPROVED General Electric surge-crest ammeter for use with the recently introduced magnetic-link method of measuring the magnitude and polarity of lightning surge currents in transmission line structures, is now available.

The magnetic-link method was tried out last summer in investigations conducted jointly by the General Electric Company, the Pennsylvania Power and Light Company, and the Appalachian Electric Company. Results were eminently satisfactory and indicated that a useful tool had been added to those already available for working on the lightning problem.

Procedure with this method is simple, as is the equipment employed in carrying it out. The magnetic links themselves are small cartridges of magnetic material about the size of one and one-half inches of lead pencil. They are carried under non-magnetic clips on small wooden brackets mounted on transmission tower legs or cross arms. Lightning current, passing to or from ground through the tower leg or arm, creates a concentric field which magnetizes the link in direct proportion to the highest value of the surge. Line patrolmen, with little compass-like instruments, detect the magnetized links during regular inspection tours and remove them for measurement by the laboratory. At other times, when the approximate location of a lightning-caused flashover has been determined by other means, a local check-up on the magnetic links will indicate the

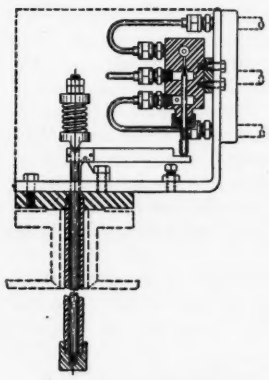
exact tower where the fault occurred.

The new surge-crest ammeter for measuring the degree of magnetization of the links sent in from the line, is a combination of two indicating instruments in series with a flashlight cell and a rheostat. One of the instruments is a milliammeter by which the current through the combination is read. The other is essentially a milliammeter—but without a magnet—so constructed that the magnetized link, when properly inserted between convenient clips on the outside of the case becomes the magnet of the instrument. When a given current flows through the combination, therefore, the deflection of the special instrument depends upon the degree of magnetization of the link and indicates directly the crest value of the lightning surge current.

This ammeter is not sensitive to or affected by nearby magnetic materials, such as objects of iron or steel, or by stray magnetic fields.

Thermo Master Regulator

To control the temperature of steam after it has passed through a reducing and desuperheating station, the Swartwout Thermo Master Regulator has been developed which consists of a thermostat made up of two different pieces of metal having different co-

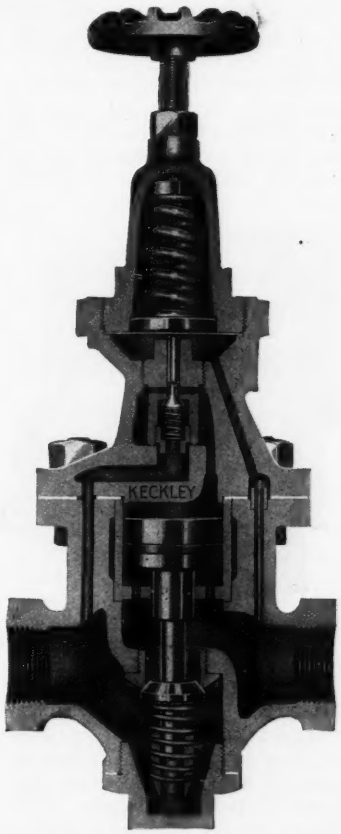


efficients of expansion. The operating element of the regulator is inserted in the steam line on the outlet side of the desuperheater. The power thus developed is transmitted through a lever to a three-way valve. This three-way valve admits pressure to or relieves pressure from the main diaphragm operated valve controlling the water supply to the desuperheater. It is built for controlling temperatures as high as 1000 deg. F. and incorporates special safety features for protecting working parts in event of failure of water supply to the desuperheater. All working parts are fully encased yet easily accessible for adjustment.

This regulator, a product of the Swartwout Co., Cleveland, O., can also be used on any temperature control system where one large or a number of valves may be in operation and where it is essential that accurate temperatures be maintained.

Keckley Pressure Regulating Valve

With unit pilot valve construction, stainless steel for parts subject to wear, means for adjustment while in service and other features of design which make for simplicity, the pressure regulating valve now on the market for gen-



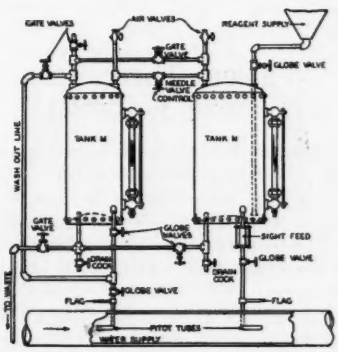
eral distribution by the O. C. Keckley Co., Chicago, Ill., has successfully completed the development stage and is now available in sizes from ½ in. to 8 in. for steam pressures ranging from 250 lb. to 600 lb.

Reference to the illustration will show that the main valve is opened by high pressure acting on the large piston directly above it. The pilot valve, working in conjunction with the diaphragm, actuated by any unbalanced effect of the adjusting spring and low pressure beneath it, controls accurately the necessary pressure to the piston. Thus the pilot valve, sensitive to the secondary pressure, opens and closes the main valve in a proportionate degree to maintain the desired constant low pressure at all times.

Stainless steel is used for the main valve seat which is inserted from the bottom of the body. The piston above the valve, where dirt and sediment will not affect its operation, rides in a cylinder liner which can be easily replaced. The pilot valve cage is screwed into the top casing as a complete unit, while directly above the pilot valve is the diaphragm held down by the adjusting spring case. Adjustment of secondary pressure is accomplished by simply turning the hand wheel.

H-O-H Eeeder System

Designed as a proportioning unit for feeding accurately predetermined amounts of liquids under varying flow conditions, the H-O-H Feeder recently developed by D. W. Haering, Inc., Chicago, Ill., uses the differential pressure between pitot tubes as a source of control. The machine is so constructed that it responds proportionately to full range flow variations, may be adjusted for any desired percentage injection of reagent, prevents dilution of reagent in the feeder, will operate at any pressure, may be recharged in less than 5 min. and uses



a sight feed indicator so that rate of feed of reagent may be checked at any time.

In operation the tank M is filled with a colored mineral base, lighter than the main fluid throughout and lighter than the reagent. This mineral base is also inert chemically and has been termed "red oil." Tank N is filled with reagent.

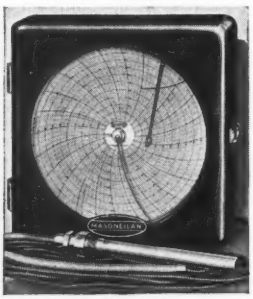
As water flows through the line

a proportionate amount rises into tank M, displacing red oil into tank N and forcing reagent into the line. The percentage injection of chemical is controlled by the needle valve setting between the two tanks.

Recharging the unit is accomplished by draining the water from tank M and opening the reagent line to tank N thus forcing the red oil into tank M and refilling tank N at one operation.

New Mason-Neilan Recording Thermometer

MASON-NEILAN REGULATOR CO., Boston, Mass., announces a new recording thermometer which may be equipped with the distinctive new over-heat protector, a safety

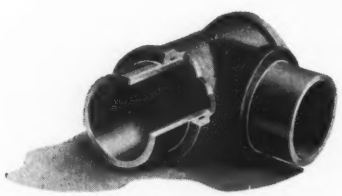


feature which definitely protects the thermal element if temperatures exceed the instrument range.

Recorders with multiple pens for recording several different temperatures can be furnished. All parts are standardized and are interchangeable with other Mason-Neilan temperature control instruments.

Walseal Threadless Bronze Fittings

THROUGH the collaboration of the Air Reduction Sales Co., Walworth Co. and Handy & Harmon, a new threadless bronze pipe fitting has been perfected. This fitting will be manufactured exclusively by the Walworth Co., Boston, Mass. It incorporates in each opening of the fitting a ring of brazing alloy, known to trade as Sil-Fos. The fitting is thus complete. The job of installing consists merely of slipping the pipe into the fittings, then applying the oxy-acetylene flame in the proper manner until the white Walseal ring appears as shown in the illustration between the pipe and the fitting outlet.

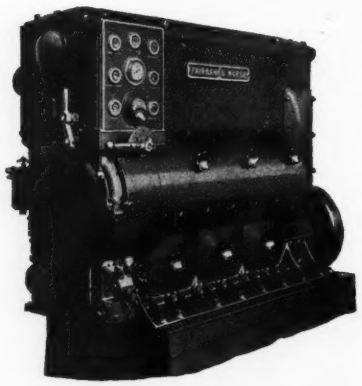


As shown in the illustration, the Sil-Fos flows out between the fitting and the pipe in both directions from the ring. The proper quantity of Sil-Fos is included in each outlet.

Should it be necessary to remove the fitting it can be used again by merely repeating the operation employed in making the original joint because there is sufficient Sil-Fos to make two complete joints.

Opposed Piston Diesel Engine

LIGHT WEIGHT and reduced space requirements of the new opposed piston Diesel constitute the latest contribution of Fairbanks-Morse & Co., Chicago, Ill., to industrial development. The weight has been brought down to 20 lb. per hp. The frame is of rigid light weight construction which together with the

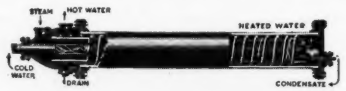


use of aluminum for parts not subjected to stress, such as cover plates, etc., makes for extreme light weight with no reduction in strength. Built-in duplex rotary scavenger blowers are provided and the uniflow principle of scavenging is employed. Other built-in auxiliaries include lubricating oil, fuel oil service and transfer and circulating water pumps.

These engines are available in five cylinder sizes, 5 by 6 in., 6½ by 8, 8 by 10, 10 by 12 and 12 by 15 in. and in 6, 7 and 8 cylinder combinations with a 5 cylinder size in the smallest bore. Power capacities range from 50 to 300 hp. per cylinder or for the engine, from 250 to 2400 hp.

Instant Water Heater Improvements

IMPROVEMENTS have been made in the Instant copper tube steam water heater now a product of the Johnson Corporation, Three Rivers, Mich., by increased baffling which includes the addition of a spiral in the cold water inlet pipe. The principle involves the use of concentric steam and water chambers made of iron pipe size copper pipe. The cold water entering the heater passes



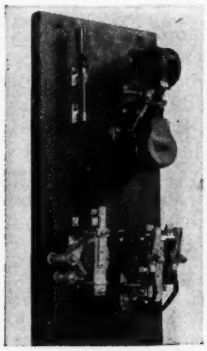
spirally through the central chamber which is surrounded by the steam in the second chamber, returning spirally in a thin sheet along the outside wall of the steam chamber creating a high velocity, turbulence and heat transfer rate.

Lowering Relay for Crane Operations

HARNISCHFEGER CORPORATION has recently developed and placed on the market a new high speed lowering relay for crane operation which increases the lowering speed of hoist drives.

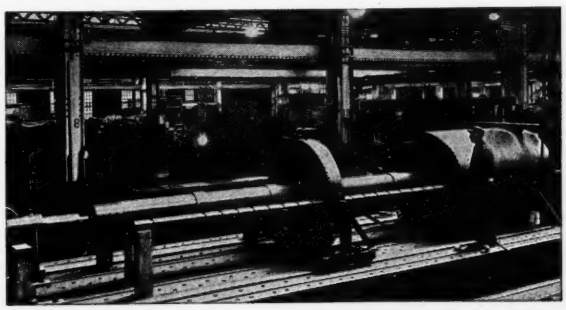
The common practice of supplying d.c. motor operated cranes with dynamic lowering control means that the hoist motor has to retard its loads in the downward direction when the load is heavy enough to overcome the frictional resistance of the drive. With the light load or no load at all, the hoist motor must drive the hook downward. As the term "dynamic lowering control" implies, dynamo action is set up in the hoist motor with the downward load, furnishing electrical energy back into the line.

Since the average load handled by most industrial cranes runs about one-third of capacity or



even less, it is desirable to establish means for lowering at greater speeds more nearly equalling the light load hoisting speeds. In developing this new device, Harnischfeger engineers have made it entirely automatic, being controlled only by the weight of the load itself. When the load is heavier than about one-third capacity the relay automatically prevents the speed increase.

This high speed lowering relay



can be applied to any d.c. motor oprated crane equipped with series motors and dynamic lowering control. It requires no serious alteration in the main controller and crane wiring. It is available for any size of hoist motor from 110 to 550 v.

Assembling Philadelphia Electric Company's New Turbo-Generator

ASSEMBLING THE rotor for the Philadelphia Company's new 183,333 kv-a. turbine generator requires extreme precision in placing each plate so that the four 6-in. diameter bolts with a clearance of 0.006 in. may be assembled by hand. The illustration shows a plate being drawn over the huge center bolt into position on a hydraulic press in the East Pittsburgh shops of the Westinghouse Electric and Manufacturing Company.

This center bolt weighs nearly six tons, is 13 in. in diameter, 310 in. long and is forged from nickel molybdenum steel. It is believed to be the biggest bolt of its kind ever made. The temporary bolts at the side are part of the hydraulic press for drawing the plates to position. The guide pins seen in the top and bottom holes in the last plate index each plate in position.

After the plates are in position, four 6-in. bolts will be pushed through by hand. Perfect positioning is necessary to allow the bolts to pass through because there is less than 0.006 in. clearance. These bolts will hold the plates between two heavy forgings. A hydraulic bolt puller exerting 1,500,000 lb. pull, stretching the bolts 3/8 in., will be used to turn on each nut by hand. Steam will be passed through a hole in the center bolt heating it to about the same elongation until its nut is in position. The complete rotor will weigh 250,000 lb.

The single cylinder generating set will consist of an 1800 r.p.m. turbine and a 165,000-kw., 3-ph., 60-cycle, 90 per cent power factor, 13,800-v., double winding generator. It will be installed at the Richmond Generating plant, on the Delaware River, Philadelphia, Pa., and will be ready for commercial service by the latter part of 1935.

Coal Utilization Course at U. of Ill.

BECAUSE OF CONTINUED requests from the industry, the College of Engineering of the University of Illinois will give a short course in Coal Utilization July 12, 13 and 14, it was announced here today by Professor A. C. Callen, head of the Department of Mining and Metallurgical Engineering.

The purpose of the course is to give technical information in a non-technical way that concerns not only the coal operator and combustion engineer, but salesman, purchasing agent and retail coal merchant. The course covers the whole field of the utilization of coal and will deal primarily with the preparation and combustion and the use of combustion equipment. One of the objectives of the course is to bring out forcibly the advantage of coal as a source of heat as compared to other fuels.

Each day's program has been divided into two parts. The morning sessions will be devoted to a series of lectures which will be continued at the same hour each day during the life of the short course. The afternoon sessions will be given over to discussions by prominent men in various phases of the coal industry, representing coal production, retailing, sales, purchasing and combustion engineering departments of producers, retailers and consumers. Lectures on the topics listed for the morning sessions will be given by staff members of the College of Engineering.

Hartford E. L. Co. Presented Coffin Award

TO THE HARTFORD ELECTRIC LIGHT CO. goes the annual award for 1933 of the Charles A. Coffin Foundation, established by the General Electric Co. The presentation of the award was made June 6 at Atlantic City to Samuel Ferguson, president of the winning company, during the annual convention of the Edison Electric Institute.

The award comprises the Charles A. Coffin gold medal, a certificate, and a check for $1000 to be deposited in the treasury of the utility's Employes' Welfare Association.

The record of the Hartford Electric Light Co. for 1933, upon which the award is based, is declared to be most impressive. In a depression year this company reduced the rates to its customers, at the same time improving the quality of its service; maintained its full force of employes at the 1929 level and without reductions in pay; paid full dividends to its stockholders, setting aside a moderate surplus, but larger than the previous year, and maintained a city-wide good will with its public.

William Mitchell McKee

WILLIAM MITCHELL MCKEE, widely known in the gas and power plant industries, both personally and as president of The Chaplin-Fulton Manufacturing Co., died at his home in Pittsburgh, Pa., on Thursday, April 26th. He was 58 yr. of age.

Mr. McKee came to this country from Ireland at the age of 18 and immediately settled in Pittsburgh, where he had remained ever since. His employment for some years was with a wholesale dry goods firm, which he left in 1910 to become auditor and eventually president of The Chaplin-Fulton Co. At national and regional gatherings of the industry with which he was connected he was a prominent and always an interesting figure.

News From the Field

I. W. Lewis, formerly president of the Riddell Stoker Co., is now in charge of the eastern division sales of Link-Belt Company's underfeed screw type stokers. His offices will be at the Philadelphia plant of the company.

Plans and Specifications are being prepared for a complete new power plant for the S. B. Foot Tanning Co., Red Wing, Minn. This will include prime movers, possible new boiler equipment, electrical work, auxiliaries, etc. Geerlings and Henschel of Milwaukee, Wis., are the engineers.

Plans and Specifications are being prepared for a complete new boiler house for the Chilton Malting Co., Chilton, Wis. Geerlings and Henschel of Milwaukee, Wis., are the engineers on the project.

Three new 330-hp. Erie City water tube boilers, fired by multiple retort underfeed stokers are being installed in the new boiler house in Northampton State Hospital as P.W.A. Docket No. 1027. Provision is being made for one additional unit to be installed as future demands require. Settings will be of the air cooled type with Carborundum protection at the fireline. The chimney will be superimposed on the roof.

Coal handling equipment, furnished by Stephens-Adamson Mfg. Co., will carry the coal from the railroad side track underneath the street and elevate it to overhead bunker. Before being discharged to the stoker hopper the coal will be weighed on a traveling larry. Yard storage and reclaiming equipment is also provided. The plant will include fire pumps, emergency electric generating equipment with provision for complete generation later.

In addition to the boiler house there will be a complete central domestic hot water supply system, using low pressure steam with a distribution piping system to all of the buildings. The ward building, approximately 500 ft. away, will be heated with low pressure steam but the main group, about a half mile from the new plant, will be heated with 60 lb. steam to be extracted from a turbo-generator.

New tunnels will be constructed connecting the new boiler room with the ward building and the main group. In addition to being used for steam, hot water and electric distribution, these tunnels will be used for patients and other passengers and for the movement of food cars.

This work is being done under the direction of E. C. Brown Co. of Boston, Mass.

L. S. Hamaker, Sales Promotion Manager of Republic Steel Corp., Youngstown, Ohio, has been advanced to the position of Vice-President and General Manager of The Berger Manufacturing Co., Canton, Ohio, wholly owned subsidiary of Republic, it is announced by B. F. Fairless, First Vice-President of Republic. The appointment was effective June 1. Mr. Hamaker began his career in the steel industry in the sales department of The Berger Manufacturing Co. and later was made Advertising Manager. During a series of mergers he became Advertising Manager of United Alloy Steel Co., Central Alloy Steel Corp., and finally of Republic Steel Corp., when that organization was formed. He was appointed Sales Promotion Manager of Republic in 1931.

The Fisher Governor Co., Marshalltown, Iowa, has announced the appointment of the Weeks Engineering Co., Harry T. Weeks, Manager, 4005 Gravois Avenue, St. Louis, Missouri, as factory representative for the St. Louis territory. Mr. Weeks has covered the industial accounts there for many years and is well qualified to handle the Fisher line of controls.

Financial Arrangements and purchase of the major equipment for the new power plant of the Watab Paper Co., Sartell, Minn., have been completed. Boiler room equipment will consist of a Bros 4-drum bent-tube boiler, to operate at 450 lb. pressure, 700 deg. total temperature, equipped with Strong-Scott pulverizers and the necessary auxiliary equipment of pumps, feedwater heaters, water treatment, air preheaters, forced and induced draft fans, and coal handling equipment. In the turbine room an Allis-Chalmers 1500-kw. back pressure steam turbine will exhaust to an existing turbine at 150 lb. ga., steam being extracted from the latter turbine for process work.

General contract for the erection of buildings, handling and financing of the boiler room equipment, on a lease agreement covering 48 months, has been given the Power Service Corp. of Minneapolis, Minn. Adolph F. Meyer and M. Dwight Bell, Associated Consulting Engineers, 904 Metropolitan Life Bldg., Minneapolis, made the preliminary investigations and successfully carried through the negotiations resulting in the final contract. They will continue to supervise the job and prepare detailed plans and make the final operating and acceptance tests.

Completion of a reconstruction schedule started in 1932 at the Massachusetts State Infirmary, Tewksbury, Mass., is under way. This program, which will provide a completed plant of four 350-hp. water tube boilers with deaerating heater, feed pumps, piping, instruments, etc., is being completed as P.W.A. Docket No. 1026. In itself this project consists of removing three present H.r.t. boilers and installing in their place two new 350-hp. water tube boilers set in the battery. Oil fuel with steam atomization is used and a new radial brick chimney and necessary flue work is being provided, together with the necessary piping to connect the new boiler to existing equipment. Chas. T. Main, Inc., 201 Devonshire St., Boston, is consulting engineer.

The Ernest E. Lee Co., Merchant Engineers in power plant equipment, has recently moved its offices from Adams Express Bldg., to the Monadnock Block, 53 W. Jackson Blvd., Chicago.

To improve its service to the local trade, Link-Belt Co. has recently opened a warehouse at 413-15 Second Avenue, Dallas, Texas, where stocks will be carried of Caldwell and Link-Belt conveying and power transmitting machinery. E. G. Wendell is resident manager.

Isometer Co. has been reorganized and is now known as the Isometer Corp. Officers of the new organization are Eugene F. Eckel, President; V. W. Eckel, Secretary, and F. Ralph Fisher, Treasurer. The office and factory is located in Elgin, Ill.

Combustion Engineering Co., Inc., New York City, announces that B. J. Cross has rejoined this organization and will be engaged in development and research work in the engineering department. Also William Lloyd for many years identified with the design, manufacture and sale of Coxe stokers, has again become associated in the engineering department of this organization.

The Pennsylvania Society of Professional Engineers has recently been organized under a state charter to promote the interests of the engineering profession in Pennsylvania. Every professional engineer registered in Pennsylvania is invited to share in this united effort to benefit the profession. All licensed engineers, irrespective of their special branch, are joined in this unified society.

Chapters are being organized throughout the state and anyone interested in forming a chapter in his locality will receive the support of the state society. The Society has also joined with the New York State Society and other state societies in the formation of a National Association of Professional Engineers.

Communications can be made to the Executive Secretary, Widener Building, Philadelphia, Pa.

Built of Light Aluminum Alloys, the new 164 passenger Diesel electric train, being built by the Goodyear-Zeppeline Corp. for the New York, New Haven & Hartford R. R., averages 80,000 lb. to the car, a reduction of 100,000 lb. from the average weight of a first class conventional railway passenger coach.

Powered by two 400-hp. Westinghouse Diesels, direct connected to electric generators, the new Rail-Zeppelin, which is scheduled for operation shortly after the first of the year, will be capable of a sustained speed of 90 m.p.h. and will maintain a 45 min. schedule over the 43.78 mile route between Boston and Providence. This three car train, which will be streamlined top, sides and bottom, is 207 ft. long.

Stanley A. Knisely has recently been appointed sales promotion manager for the Republic Steel Corp. with headquarters at Youngstown, Ohio. Mr. Knisely is a native of Canton, starting his career in the newspaper field and from 1927 to 1933 was director of advertising for the Steel Trade Extension Committee of the National Association of Flat Rolled Steel Manufacturers.

Appointment of D. A. Nemser as development engineer of The International Nickel Co., with headquarters at Hartford, Conn., is announced by Dr. J. F. Thompson, vice-president of the Company, coming from 10-yr. work with Pratt & Whitney Co., the last 5 yr. as chief metallurgist, Mr. Nemser will collaborate with New England manufacturers on problems of selection, heat treatment and utilization of nickel alloys of steel, cast iron and other metals.

For the Engineer's Library

D. G. C. Trap & Valve Co., Inc., New York City, is distributing a leaflet describing the new Cryer Inverted Bucket Trap, its construction, operation and installation.

The Carbondale Machine Co., Carbondale, Pa., has recently issued its bulletin No. 1233 which illustrates and describes in detail the safety head, trunk type pistons, shaft, wrist pin, etc., of the Carbondale duplex vertical ammonia compressors. The bulletin includes a table of sizes, also installation and manufacturing photographs.

The Parker Appliance Co., Cleveland, Ohio, has issued its bulletin No. 35 which lists the various products manufactured by this company and contains information of value to those charged with the specification and installation of products in the company's field, such as tube couplings and associated equipment.

The Paul B. Huyette Co., Inc., Philadelphia, Pa., has just issued a new catalog designated as A-34 which lists the power plant equipment instruments distributed by this company.

The Deming Co., Salem, Ohio, is distributing its new catalog No. 30 under the title New From Start to Finish. The information given includes many illustrations and drawings of Deming pumps, water systems and auxiliary parts together with general descriptions, engineering data, tables and other technical information which has been carefully arranged for easy reference.

C. F. Pease Co., Chicago, Ill., is sending out a description of its Model 11 continuous blue-printing, washing, developing and drying machine, which takes roll paper up to 42 in. wide, and operates at speeds of 4 in. to 12 ft. per min. Superactinic arc lamps, improved glass, roll application for chemicals, spray washing and oilite bearings are some of the improved features.

Frick Company, Inc., Waynesboro, Pa., has recently issued two bulletins. The first is Bulletin No. 203-B describing the construction and application of patented electrical control valves for refrigerating plants. The second is Bulletin No. 112-D, on ammonia compressors showing the installation in various industries, construction of the compressors, the general principles of refrigeration, capacity, control and dual pressure operation.

Linde Air Products Co., New York, N. Y., is issuing a new edition of its 8-p. pamphlet entitled, The Progress of Bronze-Welding, containing a comprehensive and instructive story of bronze-welding in all its phases. Also a 5-p. pamphlet on The Principles of Bronze-Welding, giving the underlying theory of the flow of bronze-weld material and elements of welding techniques.

32-page illustrated catalog No. 1415, with horsepower and other engineering data and dimension diagrams, has recently been issued by Link-Belt Co., Chicago, covering single, double and triple reduction units of herringbone gear type; also a full line of flexible couplings.

Data and Price List of the Medart Co., St. Louis, Mo., a 42-page, loose-leaf booklet is available on request to those interested in multiple and fractional horsepower V-belt drives.

Edward Valve & Mfg. Co., Inc., East Chicago, Ind., in a new 48-page booklet designated as Bulletin 11-T, discusses the desirable characteristics of boiler nonreturn valves and presents photographs of a number of installations, views in the company's metallurgical laboratories and a condensed catalog of products.

Ingersoll-Rand Co., New York City, has issued a new bulletin on their Utility air hoists which describes both the single drum air hoist used for such work as hoisting materials, moving timbers, spotting cars, etc., and the double drum air hoist which is used for slushing out material in mining work, loading cars, drag line excavations and similar operations.

Johns-Manville, New York City, in a bulletin recently issued discusses the properties of Transite Electrical Conduit giving full information on sizes, weights and list prices, details and dimensions of fittings, a description of the installation methods and a specification for the material. Transite Electrical Conduit is made of asbestos fiber and Portland cement, thus making it fire proof, highly corrosion-resistant and immune to electrolysis.

Foster-Wheeler Corp., New York City, has issued a new bulletin dealing with waste heat boilers and water heaters designated as bulletin WHB-34-1. In this bulletin various applications of waste heat muffler boilers as applied to Diesel engines, natural gas engines and blast furnace gas engines are described. The boilers described are of the extended surface, armored type consisting of steel water tubes on which are shrunk cast-iron extended surface rings.

Jenkins Bros., New York, N. Y., recently prepared an unusual piece of valve literature in the form of a 12-in. cut-out replica of a Jenkins standard iron body gate valve. This cut-out is next best to having the real valve for inspection, as it provides an exact reproduction of both the exterior and the mechanism of a big, heavy valve.

Robins Conveying Belt Co., New York City, has recently issued three bulletins designated as No. 89, Gyraloy and Super-Gyraloy Screen Cloth, No. 90 Robins Gyrex Screens and No. 91 Chance Sand Flotation Process for Cleaning Bituminous Coal. All three of these bulletins are descriptive of equipment used about power plants and contain information valuable to the engineer in making choice of equipment.

Allis-Chalmers Mfg. Co., Milwaukee, Wis., is distributing a recently published folder dealing with squirrel cage induction motors. The folder illustrates details of construction and the distinctive features which characterize this particular type of motor.

Johns-Manville, New York City, has just published a folder dealing with Sil-O-Cel C-22 brick which is an insulating refractory used in the construction of all types of furnaces. The folder contains engineering information on this insulating material including data on conductivity, strength, permeability, expansion, deformation under temperature and resistance to spalling.

Foster Wheeler Corp., New York City, has just issued its bulletin P-34-2 dealing with the subject of pulverized fuel equipment. This bulletin is well illustrated with halftones and line drawings which together with well prepared text material gives the reader a comprehensive idea of the latest equipment manufactured by this company for the preparation of pulverized fuel for use in power plants.

A 12 page catalog, entitled Type CM-2 Heavy Duty Network Protectors, has recently been announced by the Westinghouse Electric & Manufacturing Company. In it are described the latest refinements in all types of network protectors for heavy duty service including submersible and open-type units, transformer-mounting units and a compact unit for temporary use on new construction.

Flexible Steel Lacing Co., Chicago, Ill., has just published a 72 page illustrated hand book for belt users entitled, "Short Cuts to Power Transmission." This book is a thorough revision, with new chapters added, of a book with the same title which the company has published in years past. It contains information needed in solving ordinary belt transmission problems, a discussion of belting of all types, extremely informative material on the subject of belt joints and good transmission practice, besides useful tables and data.

Mechanical Power Transmission. By Robert W. Drake. Published by American Leather Belting Association, 41 Park Row, New York City. Size 8½ by 11 in., paper bound, 220 pages. Price 25 cents. (This price limited to first edition.)

Practical pointers on the application, operation and maintenance of all kinds of motor drives, including multiple V-belts, chains and gears, with chapters on the subject of individual versus group drives. The book is divided up into 50 reports on various phases of the subject and although the major portion of the space is devoted to motor drives, the steam, gasoline and Diesel engine have not been neglected.

Engineering Experiment Station, University of Illinois, Urbana, Ill., recently issued five bulletins. Circular No. 22 by William R. Morgan deals with the condensation of moisture in flues from various types of fuels, considered primarily from the standpoint of residential heating.

Circular No. 23 by Herbert F. Moore and Glen N. Krouse deals with the repeated stress testing machines used in materials testing laboratory of the University of Illinois. Bulletin No. 263 by Wilbur M. Wilson gives tests on the bearing value of rollers of the type used as expansion rollers and rockers of girder and truss bridges. Bulletin No. 264 by Herbert F. Moore and P. E. Henwood discusses the strength of screw threads under repeated tension. Bulletin No. 265 by Cloyde M. Smith gives the results of the application of model tests to the determination of losses resulting from the transmission of air around a mine shaft-bottom bend. These tests indicate that useful results can be obtained from small scale models in designing such important units as bends and splits in aircourses. Prices range from 25 to 40 cents, but a limited number are available for free distribution.

Power Plant Construction News

Calif., Isleton—Golden State Asparagus Co. plans installation of motors, conveyors and other electric power equipment in connection with rebuilding of canning plant, recently destroyed by fire with loss over $100,000. It is understood reconstruction will include a boiler house.

Calif., Los Angeles—Knudsen Creamery Co., 1957 Santee Street, plans installation of electric power equipment, conveying and other mechanical handling apparatus, in new one and two-story plant units. Entire project will cost about $50,000. Ryan A. Grut, 1007 South Grand Avenue, is engineer.

Colo., Denver—Continental Can Co., 1 Pershing Square, New York, N. Y., plans installation of electric power equipment in new plant at 235 South Cherokee Street, Denver, where tract of land and two large factory units have been acquired. Structures will be remodeled and improved, and can manufacturing works of R. Hardesty Mfg. Co., Denver, a subsidiary, removed to new location with new machinery installation for increased output. Cost over $80,000.

Ga., Lindale — Pepperell Mfg. Co. plans installation of electric power equipment in new three-story and basement dyehouse addition at local cotton mill. Entire project reported to cost close to $100,000.

Ind., Evansville—Weil Packing Co., 1700 Oakley Avenue, plans construction of new two-story cold storage and refrigerating plant, 59 x 105 ft. Cost over $40,000 with equipment. H. Peter Henschien, 59 East Van Buren Street, Chicago, Ill., is engineer.

Ind., Terre Haute—Merchants Distillery plans installation of electric power equipment in connection with expansion and improvement program. Entire project to cost over $50,000. Thomas Beggs is president.

Iowa, Fort Dodge — Tobin Packing Co., Rochester, N. Y., T. M. Tobin, president, care of H. Peter Henschien, 59 East Van Buren Street, Chicago, Ill., engineer, plans installation of electric and steam power equipment in new multi-unit meat packing plant on tract of land recently acquired at Fort Dodge. Entire project is estimated to cost over $200,000.

La., New Orleans — Cuban-American Distillers, Inc., 100 Poydras Street, plans installation of power equipment, tanks, vats, conveyors and other mechanical equipment, in new two and three-story distillery at Louisa and Chartres Streets. Entire project reported to cost over $60,000. Charles Mitchell is head.

Md., Baltimore—Gold Dust Corporation, 53 Holabird Avenue, Baltimore, with headquarters at 88 Lexington Avenue, New York, plans installation of boilers and auxiliary steam power equipment, pumps, kettles, etc., in new addition to local plant. Entire project estimated to cost close to $200,000. Lockwood, Greene Engineers, Inc., Rockefeller Plaza, New York, is consulting engineer.

Mich., Jackson — Consumers Power Company, Jackson, plans extensions in transmission lines, power substations, and distributing facilities, in connection with acquisition of properties of the Michigan Federated Utilities Co., operating at Mt. Clemens, Owosso, Marshall and vicinity, and properties of Lower Peninsula Power Co., serving Frankfort, Plainwell and neighboring territory. Company engineering department in charge.

Mich., Kalamazoo — Reference in these columns last month to new street lighting system at this place, to cost about $60,000, was incorrect. City Department of Public Utilities has recently secured appropriation in amount noted for purchase of cables, transformers, meters and other equipment for extensions in commercial distributing system, and reports that purchases for majority of requirements have been made.

N. H., Portsmouth — Frank Jones Brewing Co. plans installation of electric power equipment in brewing plant rebuilding, following recent damage by fire. Loss over $75,000.

N. J., Harrison — Reynolds Metals Co., 19 Rector Street, New York, N. Y., manufacturer of tin foil, foil surface papers, etc., plans installation of electric power equipment in new plant at Cross Street and Kingsland Avenue, Harrison, where company has acquired group of buildings formerly used by Edison Lamp Works. Will remodel and equip at once. Cost over $75,000.

N. J., Newark—Breeze Corporations, Inc., 24 South Sixth Street, manufacturer of aircraft parts and equipment, plans installation of electric power equipment, conveyors and other mechanical equipment in new one and two-story, multi-unit plant at Newark Airport. Entire project will cost over $250,000. Frank Grad, 1172 Raymond Boulevard, Newark, is architect.

N. J., Paterson—Wollner Fringe & Cord Co., Inc., 235 Preakness Avenue, plans installation of electric power equipment in connection with rebuilding of portion of mill recently destroyed by fire. Loss about $45,000.

N. J., South River—American Enameled Brick Corporation plans installation of power equipment, conveyors and other mechanical equipment in new local one-story plant, to replace works recently destroyed by fire. Entire project reported to cost over $350,000.

N. J., Woodridge—Cellofilm Corporation plans installation of electric power equipment in connection with rebuilding of portion of chemical works, recently destroyed by fire with loss estimated over $40,000.

N. Y., Albany—Atlantic Refining Co., 260 South Broad Street, Philadelphia, Pa., plans installation of pumping machinery and auxiliary equipment, tanks, etc., for new bulk oil storage and distributing terminal on Hudson River waterfront, in Rensselaer district, Albany, where tract of about 35 acres of land has been acquired. Entire project will cost over $400,000.

N. Y., Bayside (Long Island)—Board of Education, Park Avenue and Fifty-ninth Street, New York, N. Y., plans installation of large boiler plant in new multi-story high school on Thirty-second Avenue, Bayside. A fund of $2,500,000 has been arranged for structure. W. C. Martin is architect and superintendent of school buildings.

N. Y., Long Island City—First National Oil Corporation, 29-27 Forty-first Avenue, plans installation of pumping machinery, tanks and other mechanical equipment at new bulk oil storage and distributing plant on East River, vicinity of Vernon Boulevard. Entire project will cost about $85,000.

N. Y., Peekskill — Standard Brands, Inc., 295 Madison Avenue, New York, N. Y., plans installation of electric power equipment in new four-story gelatine manufacturing plant at Peekskill, 50 x 280 ft. Entire project reported to cost over $125,000. Company will also install similar equipment at new multi-unit plant at Oakland, Calif., for which superstructure will proceed at once. Latter project will cost more than $700,000.

Ohio, Dayton—Inland Mfg. Co., Dayton, a subsidiary of General Motors Corporation, General Motors Building, Detroit, Mich., plans installation of electric power equipment in new addition to automobile parts manufacturing plant, entire project estimated to cost close to $300,000.

Pa., Forty-Fort — Henry German Baking Co. plans installation of steam power equipment, ovens, conveyors, etc., in connection with rebuilding of portion of local baking plant, recently damaged by fire. Loss about $35,000.

Pa., Johnsonburg—Johnsonburg Radio Corporation plans installation of electric power equipment in proposed new two-story plant addition, and improvements in present factory. Cost over $65,000.

Pa., Sayre—Sayre Electric Co., operated by Northern Pennsylvania Power Co., Binghamton, N. Y., plans rebuilding of portion of local power substation, recently destroyed by fire, with loss estimated close to $24,000 with equipment.

Pa., Uniontown—Uniontown Distilling Syndicate plans installation of electric power equipment in connection with expansion and improvement program for large increase in present capacity. Company has arranged financing in amount of $789,750, portion of proceeds to be used for work noted. M. E. Minert, Uniontown, is head.

Tenn., Knoxville—Tennessee Valley Authority, New Sprankle Building, Dr. Arthur E. Morgan, chairman, plans early construction of four new power dams for hydroelectric power development in connection with power project now in progress at Muscle Shoals, Ala., Clinch River, Tenn., and other parts of Tennessee Valley district. A fund of $48,000,000 is being arranged for power dams noted. Entire development will approximate $130,000,000 including transmission lines and other structures.

Wash., Sumner — Washington Wineries, Inc., recently organized, care of Mock & Morrison, Perkins Building, Tacoma, Wash., architects, plan construction of one-story steam power house and refrigerating plant in connection with new local winery, entire project to consist of group of one-story units, reported to cost close to $100,000. Robert J. Rayson is president. Architects noted are in charge.